# SCIENCE ABSTRACTS.

## Section A.—PHYSICS.

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**FEBRUARY 1914.**

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## GENERAL PHYSICS.

177. ***Transit Micrometer with Personal Equation.*** **A. Claude** and **L. Driencourt.** (Comptes Rendus, 157. pp. 685–687, Oct. 27, 1913.)—One of the chief difficulties in observations of star transits for time determination is the personal equation involved in the estimation of fractions of the interval between successive beats of the clock or chronometer. The authors propose to eliminate this by a special form of reticule in which the distances between the threads may be changed so that for any star the interval between the threads may correspond exactly to the interval between the beats of the clock. This is done by the reticule frame being in the form of a hinged rectangular frame, the motion being controlled by a graduated screw. When the frame is square on, the intervals are adjusted to be correct on an equatorial star ; for other stars the rectangle is converted into a rhombic figure depending on the declination of the star, thus diminishing the distance between the threads so that they still correspond to the same interval of time. C. P. B.

178. ***The Kilowatt as the Unit of Power in the Metric System.*** **G. Darrieus.** (Lumière Électr. 24. pp. 336–337, Dec. 13, 1913.)—The author points out the many advantages that accrue from adopting the kilogramme as the standard of mass, and the metre as the unit of length. The unit of force, for example, would be the force that would have to be applied to the mass of 1 kg. in order to give it an acceleration of 1 m. per sec. per sec. It would therefore equal $10^5$ dynes. The suggestion has been made that this unit be called the *cop*, from Copernicus. The unit of work in this system would be $10^5 \times 10^2$, that is, $10^7$ ergs or the joule. The unit of power also would be the watt. Numerical examples are given to show how engineering calculations would be very appreciably simplified if we adopt the metre-kilogramme-second system. A. R.

179. ***Kilogramme Force and Kilogramme Mass.*** **A. Berger.** (Zeitschr. Vereines Deutsch. Ing. 57. pp. 1628–1634, Oct. 11, 1913.)—A controversial

discussion of Mass, Inertia, Weight, and Quantity of Matter. Points out certain advantages of a cm.-force unit-second system, and proposes the kg. weight as a unit of force. **E. Budde** points out that in Germany the kilogramme is already, by law, a unit of mass. A. D.

180. *Validity of Stokes' Law for Small Drops of Liquid moving in a Liquid.* **I. Nordlund.** (Ark. för Mat. Astron. och Fysik, Stockholm, 9. No. 13. pp. 1–18, 1913.)—Describes two series of experiments undertaken to examine the validity of Stokes' law (and of some corrections that have been applied to it, notably by Rybczynski and Hadamard) in the case of small drops of liquid moving in a liquid medium. The first series, of 69 experiments, was made with drops of nitrobenzol falling in water already saturated with nitrobenzol, the diam. of the drops being measured directly by means of a microscope. The rate of fall was found to be 1 % higher than was to be expected from Stokes' law (as modified by Ladenburg). This was found to be due to the rapid loss of saturation of the solution employed, even when the temperature remained constant. Hence a second series of 105 experiments was made with drops of Hg falling in a mixture of glycerine and water. In this case the difference was only 0·076 %. In both results Rybczynski's modification would have introduced an enormously greater discrepancy. Hence it appears that the Stokes-Ladenburg law holds rigorously for the cases investigated, and that it is therefore legitimate to apply Einstein's formula to the Brownian movement of liquid drops in a liquid medium. The author promises the results of his experimental determinations, made by this method, of Avogadro's constant.

J. W. T. W.

181. *Forces Acting on a Solid Sphere in Contact with a Liquid Surface* **A. Ferguson.** (Phil. Mag. 26. pp. 925–934, Nov., 1913.)—Introduces a closer approximation into the equation giving the force required to detach a circular disc from the surface of a liquid. The angle of contact of the liquid along an edge is, however, very uncertain, and hence the author discusses the case of a sphere of large radius substituted for the disc and suspended so that its lowest point is exactly level with the general surface of the liquid. He deduces, by the method of successive approximations, an equation for this case, giving, when the contact angle is zero, the force required to maintain the sphere in this position. He uses a glass sphere so suspended to determine experimentally the surface tensions of benzene, alcohol, and water, and obtains exceedingly consistent results. J. W. T. W.

182. *Observation of Brownian Movements.* **F. Bourrières.** (Comptes Rendus, 157. pp. 1416–1417, Dec. 22, 1913.)—A method is described of observing Brownian movements with magnification greater than 20,000. In place of the ordinary ocular of a microscope is placed a second complete microscope, giving an arrangement of very great magnifying power. A Zeiss objective DD was used in the first microscope, having a magnifying power of about 50. The microscope replacing the ocular of the first gave a magnification of 400, so that the total magnification was about 20,000. The ultramicroscopic illumination was given by a simple Nernst lamp with the arrangement of Cotton and Mouton. A colloidal solution of silver was prepared with special care and on investigation with the above arrangement the Brownian motion appeared to be composed of two movements: the first, with amplitude of the order of 1 $\mu$, rather sharp, but very smooth and

elastic, occupying all the field; the second, with amplitude of the order of $0{\cdot}02\,\mu$, of a lively vibratory nature. In practice it is advisable to pass gradually to the enormous magnifications obtainable by this method.

A. W.

183. *Turbulent Flow of Water and Mercury through Capillary Tubes.* **G. Lechner.** (Ann. d. Physik, 42. 8. pp. 614–642, Oct. 16, 1913. Extract of Dissertation, Würzburg.)—Describes research on the effect which capillary tubes of spiral form have in starting turbulent flow, and also deals with the effect of altering the radius of the capillary. The results show that as the number of coils of the spiral capillary increases the turbulence also increases, and the Reynolds criterion for the critical velocity does not in general hold good. The critical velocity is changed to smaller values, and the change is greater the greater the radius of the capillary is. Observations with coloured fluids show that with increasing velocity the turbulence passes from the last coil of the spiral to those in front. For a straight tube with smooth walls a definite turbulence, measured by the resistance which the tube offers to the passage of the fluid, always corresponds to a given velocity; for a spiral tube this resistance is always greater. If Q is the quantity of liquid flowing through the tube per sec., P the pressure, then $Q = P/w$, where the resistance $w$ only remains constant as long as Poiseuille's law holds good. By increasing the velocity a constant, but larger, resistance is again reached, when $Q - Q_0 = P/w$. $Q_0$ decreases with the number of coils, while $w = dQ/dP$, and so is independent of the number of coils and also of the velocity. Finally $Q_0 = 0$, and thus Poiseuille's law $Q = P/w$ again holds.

A. W.

184. *Region in which Stokes' Resistance Formula is Valid.* **C. W. Oseen.** (Ark. för Mat. Astron. och Fysik, Stockholm, 9. No. 16. pp. 1–15, 1913.)—Determines an additional term to Stokes' formula to allow for the vortex motion.

E. H. B.

185. *The Weight of a Falling Drop and the Laws of Tate.* XII. *Drop-weights of Certain Organic Liquids and the Surface Tensions and Capillary Constants calculated from them.* **J. L. R. Morgan** and **E. C. Stone.** (Amer. Chem. Soc., Journ. 35. pp. 1505–1524, Oct., 1913.)—The authors have determined the drop-weights in the case of twenty-two liquids and have calculated therefrom the value of the surface tension, the results obtained being as follows:—

| Substance. | $\gamma$. | Substance. | $\gamma$. |
|---|---|---|---|
| Methyl propyl ketone | $25{\cdot}976 - 0{\cdot}1026t$ | Isovaleric acid | $26{\cdot}253 - 0{\cdot}0844t$ |
| Paraldehyde | $27{\cdot}686 - 0{\cdot}1119t$ | *o*-Toluidine | $41{\cdot}867 - 0{\cdot}1129t$ |
| Ethyl nitrate | $29{\cdot}658 - 0{\cdot}1229t$ | *p*-Toluidine | $38{\cdot}277 - 0{\cdot}0924t$ |
| Nitro-methane | $38{\cdot}534 - 0{\cdot}1423t$ | Formamide | $58{\cdot}306 - 0{\cdot}7927t$ |
| Butyl alcohol | $25{\cdot}348 - 0{\cdot}0788t$ | Dimethyl nitroso-amine | $39{\cdot}639 - 0{\cdot}1216t$ |
| Isobutyl alcohol | $23{\cdot}569 - 0{\cdot}025t$ | Acetophenone | $40{\cdot}805 - 0{\cdot}1162t$ |
| Allyl alcohol | $26{\cdot}499 - 0{\cdot}0864t$ | Benzophenone | $45{\cdot}669 - 0{\cdot}1076t$ |
| Formic acid | $38{\cdot}368 - 0{\cdot}1025t$ | Ethylpropyl ether | $20{\cdot}955 - 0{\cdot}1072t$ |
| Propionic acid | $27{\cdot}797 - 0{\cdot}1067t + 0{\cdot}000183t^2$ | Acetal | $44{\cdot}341 - 0{\cdot}1221t$ |
| Butyric acid | $26{\cdot}762 - 0{\cdot}0921t + 0{\cdot}000104t^2$ | Anethole | $36{\cdot}871 - 0{\cdot}1016t$ |
| Isobutyric acid | $26{\cdot}208 - 0{\cdot}0935t$ | | |

Of the above liquids only three, acetal, ethyl propyl ether, and *o*-toluidine, have normal molecular weight according to the Morgan definition, *i.e.* only these yield the same value for the critical temperature independent of the temperature of observation. Benzophenone was studied as much as 89°

below its melting-point in order to see if the super-cooled liquid showed any abnormalities; but none were observed. The observations previously made that the ortho-compound has always the highest surface tension, while the para-compound has the lowest, is confirmed by the toluidines. A. F.

186. *The Weight of a Falling Drop and the Laws of Tate.* XIII. *Drop-weights of Aqueous Solutions and the Surface Tensions calculated from them.* **J. L. R. Morgan** and **G. A. Bole.** (Amer. Chem. Soc., Journ. 35. pp. 1750–1759, Nov., 1913.)—In continuation of previous work [see preceding Abstract] the authors have studied the drop-weights and surface tensions of thirty semi-normal solutions. The change in surface tension with temperature was found to be linear. Some salts were found to increase the surface tension of water and some to diminish it, so that the generalisation of Valson that all normal solutions at the same temperature have identical values of surface tension becomes untenable. The acids, citric, tartaric, and oxalic, lower the surface tension of water, so that hydrolysis in the case of such salts would tend to lower the surface tension. For the most part, salts of the same acid show a marked agreement in their values for the surface tension at the same temperatures, but there are also decided exceptions to this generalisation. The surface tension of a solution of two salts, one of which raises the surface tension and the other lowers it, is an additive property of the two separate solutions, provided no chemical reaction takes place between them and the values for the two are not very far removed from the value for water. If one of the solutes causes much larger effect than the other, the value for the mixture lies closer to the one with the greater effect. A. F.

187. *"Suction" between Passing Vessels.* **A. H. Gibson** and **J. H. Thompson.** (Inst. of Naval Architects, Trans. 55. 2. pp. 61–73; Discussion, pp. 74–75, 1913. Engineer, 116. pp. 22–24, July 4, 1913.)—A more complete account of the work dealt with in Abstract No. 1617 (1912).

188. *On the Criterion for the Occurrence of Cavitation.* **L. Gümbel.** (Inst. of Naval Architects, Trans. 55. 2. pp. 118–123; Correspondence, pp. 124–136, 1913. Engineering, 96. pp. 76–77, July 18, 1913.)

189. *Variability of the Velocity of Ascent of Registering and Pilot Balloons.* **R. Dietzius.** (Akad. Wiss. Wien, Ber. 122. 2a. pp. 543–605, March, 1913.)—Besides vertical currents there are a number of causes which make the velocities of ascent of pilot and registering balloons variable. Some of the causes vary gradually with the rates of ascent and are therefore of little importance, others, such as the varying difference of temperature between the gas in the balloon and the free air outside, produce considerable fluctuations in the rate. With registering balloons, the rate of ascent is much more subject to disturbance than with pilot balloons and this result is confirmed by observation. The determination of the rate of ascent of a given balloon at a given height assuming absence of vertical currents, and of the magnitudes of the vertical currents by a comparison of the observed and computed rates of ascent is a more complicated problem than is often considered to be the case.

R. C.

190. *On the Relation between the Cloudiness of the Sky and the Duration of Sunshine.* **J. P. van der Stok.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 507–521, Dec. 27, 1913.)—A mean value for the proportion of the

sky which is covered by clouds may be arrived at in two ways: (1) from the recorded percentage of the possible duration of sunshine, and (2) from normal estimates of cloud amounts. Both these methods are rendered inaccurate by the fact that clouds are not horizontal laminæ but have vertical depth, so that clouds near the horizon appear to cover more of the sky than their horizontal area warrants. If the sun were in the zenith obviously the method (1) would be free from this source of error, and summer observations will be less affected than winter ones by it. From a comparison of the results obtained by the two methods at certain stations in Holland the author attempts to determine the mean ratio of vertical depth to horizontal diameter of clouds. J. S. Di.

191. *On Interference Colours in Clouds.* **R. H. Goddard.** (Science, 38. pp. 881–882, Dec. 19, 1913.)—The author has noticed that often by careful observation faint tints may be observed on clouds about 15° from the sun. The colours are usually red or green; they appear in irregular patches and are totally different from rainbow effects. In the paper it is suggested that the colours are due to interference produced by a thin cloud of small water-drops of homogeneous size, the colour effect being the same as that produced by a soap film. J. S. Di.

192. *Wolf Sun-spot Numbers,* 1901–1912. **A. Wolfer.** (Mount Weather Observatory, Bull. 5. pp. 365–368, 1913.)—In continuation of the series of Wolf sun-spot numbers published for the period 1749–1900, new tables are given by Wolfer, of Zurich, showing the sun-spot numbers on the same system for the period 1901–1912. Both observed and smoothed values are tabulated. The period indicated is 11·111 years. C. P. B.

193. *Harmonic Analysis of Sun-spot Cycle.* **A. A. Michelson.** (Astrophys. Journ. 38. pp. 268–274, Oct., 1913.)—By means of mechanical integration with the harmonic analyser [Abstract No. 241 (1898)] the values of the coefficients of a Fourier series may be obtained with ease and considerable accuracy. The given function is copied on the machine, which then draws a curve whose ordinates at given distances along the axis of abscissæ are proportional to the coefficients of the corresponding Fourier series. A table is given showing the periodicities determined from such analysis of the sun-spot curve from 1750 to 1910. The curves as given do not extend beyond the 6-year period, but in another case they have been extended to something less than the 8-year period, with no certain indications of anything like a period of 8·86 years, or of 4·79 years. It would appear that with the exception of the 11-year period, and possibly another of the order of 100 years' the many periods found by previous investigators are illusory. C. P. B.

194. *Radial Motion in Sun-spots.* **C. E. St. John.** (Observatory, No. 466, pp. 395–397, Oct., 1913. Paper read before the British Assoc. at Birmingham.)—Observations of sun-spot spectra, for the investigation of the radial motion found by Evershed in 1909, were commenced in 1910 with the powerful 60-ft. tower equipment at Mount Wilson. Some 500 lines were specially examined, representing a wide range of intensity and belonging to 26 different elements. The most striking feature of the results is the systematic dependence of the displacements, in amount and sign, upon the intensities of the lines, and their variation with wave-length in the case of lines of the same solar intensity. In one important point these results differ from those obtained by Evershed, in

that the displacements do not disappear abruptly at the outer boundary of the penumbra, but gradually fade away. The observed displacements vary from 2·04 km. per sec. for lines of intensity 00 to 0·24 km. per sec. for lines of intensity 10, and indicate an outflow of the vapours from sun-spots, tangential to the solar surface. The displacements are not equal for lines of equal intensity of all elements, and this points to differences of level. C. P. B.

195. *The General Magnetic Field of the Sun.* **H. Deslandres.** (Comptes Rendus, 157. pp. 517–524, Oct. 6, 1913.)—The author reviews the various papers published by himself and others in which the idea of the sun's general magnetic field has been developed, extending over the period 1896–1913. He regards the phenomena of prominences and coronal streamers as explainable by the action of the field on streams of charged ions, the deduced strength of field being of the same order as that observed. The field strength at the base of the solar atmosphere is probably much greater than at the outer boundaries. C. P. B.

196. *Spectrum of Comet Metcalf* (1913*b*). **J. Bosler.** (Comptes Rendus, 157. p. 589, Oct. 6, 1913.)—Three photographs of the spectrum of this comet were obtained at Meudon with an objective-prism camera, 0·25 m. aperture and focal length 0·75 m. on 1913 Sept. 24, 25, 26. Exposures varied from 2h. 23m. to 3h. 30m. The spectrum shows a faint continuous band, with three sharp condensations near λ473, λ407, and λ388, closely resembling the spectrum of Comet Schaumasse. [See Abstract No. 1802 (1913).] C. P. B.

197. *Photographic Magnitudes of Selected Stars.* **C. H. Gingrich.** (Astrophys. Journ. 38. pp. 209–240, Oct., 1913.)—In the series of charts of variable stars published by Hagen comparison stars are provided over a region one degree square, with each variable at the centre. The magnitudes of these comparison stars are visual, being finally checked with the 12-in. equatorial of the Georgetown College Observatory, Washington, D.C. As so much of modern observing is done photographically, and the photographic and visual magnitudes of stars are in general somewhat different, depending on colour, etc., the present investigation was undertaken at the Yerkes Observatory with the object of providing comparison photographic magnitudes for certain of the Hagen charts. Tables are then given showing the visual and photographic magnitudes for several of the Hagen star fields, with a sample photograph showing the stars surrounding the variable S Cygni, taken with the 24-in. reflector. C. P. B.

198. *Photographic Magnitude Scale of North Polar Sequence.* **F. H. Seares.** (Astrophys. Journ. 38. pp. 241–267, Oct., 1913. Contribution from Mt. Wilson Solar Observatory No. 70.)—Photographic magnitudes of the bright stars of the Polar Sequence have been determined by comparison with the stars included between magnitudes 10·5 and 15·5. Reduction in the light was produced by combinations of screens and diaphragms whose absorption constants range from one to eleven magnitudes. The Harvard magnitudes for the faint stars were used for the comparison. Various tests indicate that a mean scale has been determined which is nearly homogeneous with that of the faint stars. A direct intercomparison of *Polaris* and two other bright stars having magnitudes 5·99 and 7·78, gave differences in brightness practically identical with those resulting from the mean scale. Comparisons of the mean scale for bright stars with the corresponding Harvard values shows a

marked divergence, nearly linear in character, the observed differences being zero at the tenth magnitude. A comparison of the mean scale with the determinations of Schwarzschild and Parkhurst, extending from magnitudes 4·0 to 7·5, gives sensibly constant differences which become zero when the Mt. Wilson magnitudes are referred to the international zero point. C. P. B.

199. *Parallax of North America Nebula.* **E. B. Andersen.** (Astrophys. Journ. 38. pp. 275–281, Oct., 1913.)—In general all that can be said with any certainty concerning parallaxes of nebulæ is that the gaseous nebulæ do not differ from the fixed stars in regard to either proper motion or parallax. Apart from the ordinary physical connection between nebulæ and stars, of which several are known (Pleiades, Orion, Lyra, etc.), the vast irregular gaseous nebulæ often seem to have a peculiar influence on the stars in their vicinity; their density may suddenly decrease to such a degree that it looks as if the nebula were placed in a dark hole. Characteristic examples of this type are Orion, $\rho$ Ophiuchi, $\xi$ Persei, North America, $\gamma$ Scuti, 15 Monocerotis, etc. It is to be noted that all these objects are in regions very rich in stars. Whatever the conditions may be in the "rifts" traversing these rich regions, it is evident that the stars which are between the earth and the nebula must be unaffected. By taking account of the star-density and parallaxes in the vicinity of these nebulæ it may therefore be possible to obtain an approximate idea of the distance of the nebula itself. In the present case this is done for the North America nebula, the result being that its parallax is indicated as being nearly equal to that of stars of 8·5 magnitude, which, leaving proper motion out of consideration, has the probable value of 0·007″. C. P. B.

200. *Giant and Dwarf Stars.* **H. N. Russell.** (Observatory, No. 464. pp. 324–329, Aug., 1913. Paper read before the Royal Astronomical Society, June, 1913.)—Starting with the comparison of brightness and spectrum, it is shown that there do not appear to be any faint white stars. All the faint stars are at least as red as class K; most of them are K5 or M; all of the stars of classes A or B, especially the latter, seem to be many times brighter than the sun. On the other hand, the converse is not true; there seems no doubt that there exist many very bright red stars, Arcturus, Aldebaran, Antares, etc. Taking the reddest stars (classes K and M), they are divisible into two groups, one containing very bright stars, the other containing stars diminishing rapidly in brightness with increasing redness. The stars of class B may be regarded as belonging to either series, and the two groups intermingle for class A and are probably not really separated in class F. These different series of stars were first noticed by Hertzsprung, and were designated by him "giant" and "dwarf" stars. It would thus appear that the absolute mass of any star may be regarded as a function of its mass density, and surface brightness. It is concluded that the differences between the giant and dwarf stars do not arise from differences of mass.
C. P. B.

201. *Fundamental Star-places.* **R. Trümpler.** (Gesell. Wiss Göttingen, Nachr., Math. Phys. Klasse, 2. pp. 249–285, 1913.)—A full description is given of the method of determining fundamental star-places, with examples of the system of reduction of the observations. C. P. B.

## LIGHT.

202. *Medial-telescope of Short Focus.* **L. Schupmann.** (Zeitschr. Instrumentenk. 33. pp. 308–312, Oct., 1913.)—A description is given, with sketches showing the disposition of the various parts, of a short-focus type of telescope of special design, called the medial-telescope. The chief characteristic is the combination of lens and mirror systems for shortening length of body and correcting certain of the aberrations. C. P. B.

203. *Grating Spectrograph for Radial Velocities.* **M. Hamy.** (Comptes Rendus, 157. pp. 666–671, Oct. 27, 1913.)—An interesting modification of grating spectroscope is described, the chief necessity being a diffraction grating giving two spectra of nearly equal intensity. A single collimator is employed, normal to the grating, and for stellar spectra no slit would be needed, thereby rendering it possible to photograph the spectra of several stars at the same time. C. P. B.

204. *Chromatic Aberration of Telescope Objectives.* **H. Fassbender** and **A Wetthauer.** (Zeitschr. Instrumentenk. 33. pp. 265–277, Sept., 1913. Communication from the Physikal.-Techn. Reichsanstalt.)—Tables are given of the variations in focal length for light of selected wave-lengths from red to blue, for several of the large objectives of national observatories, and for several types of spectroscopic objective. The results are also presented as curves showing the differences of focus in mm. for different portions of the spectrum. C. P. B.

205. *Determination of Zonal Variation of Equivalent Focus.* **E. D. Tillyer.** (Washington Acad. Sci., Journ. 3. pp. 481–484, Dec. 4, 1913.)—Hartmann's method of lens-testing is laborious when applied to zonal variations. The present author proposes a method for finding both the variations of the position of the focus and of the equivalent focal length from one set of measures. By making several sets in light of different wave-lengths, the axial and oblique aberrations can also be obtained. A nearly parallel beam of light from a distant monochromatic source falls upon a metal plate pierced with holes of 1 mm. diam., arranged in a line at about 3-mm. intervals. The rays through the holes are then refracted through the lens system to be tested. A shadow photograph is taken upon a plate placed close to the lens, a second at a considerable distance on the other side of the focus. The shadowgraphs are measured on a small Zeiss comparator. If a ray passing through a hole distant $h$ from the axis meets the two plates at distances $a$ and $b$ from the axis, and cuts the axis at distance $v$ from the first plate, we have $v = ad/(a + b)$, $d$ being the interval between the plates. For an object at infinity, we have $E = h/\sin u$, where E is the equivalent focal length, $h$ the distance from the axis of the entering ray, and $u$ is the angle this ray makes with the axis after refraction. The length $h$ is read off on the metal plate; the angle $u$ can be obtained from $\tan u = (a + b)/d = a/v$, and consequently E and $\Delta E - \Delta v$. A. E.

206. *Achromatism and Anastigmatism in Photographic Doublet.* **H. C. Lord.** (Astrophys. Journ. 38. pp. 297–300, Oct., 1913.)—In the course of

applying Taylor's method of discussing aberrations of lens systems to the type of photographic objective consisting of four separated thin lenses arranged in the form of a symmetrical doublet, a simple relation was discovered, which must be satisfied if the objective is to be as free as possible from chromatic and astigmatic errors. This may be stated thus :—"The separation between the positive and negative lens minus the focal length of the negative lens must equal the focal length of the positive lens multiplied by the square root of the ratio of the indices of refraction divided by the ratio of the dispersive powers." An analytical proof is given of the proposition, based on Taylor's formula. C. P. B.

**207.** *Reflection from Fluids in Ultra-red.* **A. K. Angström.** (Ark. för Mat. Astron. och Fysik, Stockholm, 8. No. 26. pp. 1–23, 1913.)—The following substances were dealt with: Water, ethyl alcohol, methyl alcohol, benzol, toluol ; and the investigation was carried out for the spectral region 1 to 6 μ. From a knowledge of the reflecting power of the different substances the index of refraction for different wave-lengths was calculated from Cauchy's formula. Reflection maxima were found for the wave-lengths given in the following table :—

| | $\lambda$ |
|---|---|
| Water | 8·20, (1·95), (4·5) |
| Ethyl alcohol | 8·10, (4–5) |
| Methyl alcohol | 8·14, (4–5) |
| Benzol | 8·00, 8·70 |
| Toluol | 8·00, 8·70 |

The values in brackets indicate maxima not so well defined as the others, which, as shown by the curves reproduced, are all fairly sharp. A. W.

**208.** *Selective Radiation from Various Substances.* **W. W. Coblentz.** (Bureau of Standards, Bull. 9. pp. 81–117, March 15, 1913.)—In previous papers the author investigated the most important so-called constant, $a$, of spectral radiation of various metals, and it was found that the supposed constant had a temperature coefficient. This variability of $a$ was subsequently explained by noting the fact that if the reflecting power (and hence the absorptivity) were uniform throughout the whole spectrum, the emission would be that of a "grey body." Hence the position of the max. emission $\lambda_{\text{max.}}$ should shift uniformly with rise of temperature toward the shorter wave-lengths and the intensity of the max. emission should increase according to the equation, $E_{\text{max.}} = BT^a$. But the reflecting power of metals has a temperature coefficient marked in the infra-red and decreasing to a negligible quantity at 8 μ to 4 μ. Moreover, the reflecting power of metals is low in the visible spectrum, and increases rapidly to a fairly constant value beyond 8 μ. It results that the value of $E_{\text{max.}}$ is larger than it would be if the reflecting power at 1·2 μ (where reflecting power decreases at low temperatures, but at high temperatures $\lambda_{\text{max.}}$ is in the region of 1·2 μ) were the same as at 8 μ, and consequently the value of $a$ decreases with rise in temperatures [see Abstracts Nos. 672 (1910), 927 (1911), and 142 (1912)]. In a new series of investigations, without expecting to determine a radiation constant, $a$, the author has endeavoured to determine a series of spectral energy curves and also some temperature coefficients. Mendenhall's method, which is based on the proved result that the temperature determined by sighting an optical pyrometer into a V-shaped fold in a strip of metal is closely the true temperature of the metal, was employed. The spectrum energy curves were determined by means of a vacuum bolometer, mirror spectrometer, and a fluorite prism: the bolometer strip being 0·6 mm. wide and subtending an angle of 4′. Besides a series of 12 energy curves was obtained, in which the temperatures were measured by means of a potentiometer and an Heraeus thermo-couple, of wires 0·1 mm. in diam. The results are embodied in a complete set of curves and tables.

II. *Emission Spectra of Neon, Helium, and Mercury.*—The spectral-energy distribution of the radiation from various gases in vacuum tubes was given in a previous paper. The most intense lines were found to lie just beyond the red; and in the region 1·5 μ to 3·5 μ there was a complex radiation, weak in intensity and usually unresolved with the spectrometric apparatus employed. Subsequent experimenters have succeeded in resolving this latter region into separate lines. The results hitherto may be summarised by stating that in spark spectra the most intense lines are situated in the ultra-violet; that in arc and vacuum-tube spectra the most intense lines are situated just beyond the red; and that in the spectra of solids the max. emission lies far in the infra-red but shifts rapidly toward the visible with rise in temperature. From the prismatic and the normal spectral energy curves of neon taken with the present spectro-bolometric apparatus it is seen that the max. emission lies within the group of lines in the red of which the line at 0·64 μ is the brightest to the eye. The intensity of the group of lines in the region of 0·8 μ is only about $\frac{1}{20}$th that of the red. The spectrum of helium consists of fewer lines than that of neon, the most prominent one (visually) being the yellow line at 0·5876 μ. Radiometrically, however, conditions are quite different. The red lines are then found to be as intense as the yellow line. The most intense line lies at 1·083 μ. The luminous efficiency of vacuum-tube radiation (air, N, $CO_2$, He, etc.) is of the order of 15 to 20 per cent., or perhaps even much lower owing to the great amount of infra-red radiations emitted. In marked contrast with these is neon, in which the infra-red is almost entirely absent, so that its luminous efficiency is of the order of 80 to 90 per cent. The colour of this light is a rich crimson.

The spectrum of neon is composed of numerous fine lines, more than 60 of which lie between the red and yellow He-lines (0·5876 μ and 0·7065 μ). There is sufficient reason for believing that the emission lines in Ne are just as numerous at 0·8 μ to 1·0 μ as they are in the visible spectrum, so that whatever the dispersion the same energy distribution will obtain as here observed, viz. that the strongest lines occur in the region 0·6 μ to 0·7 μ of the visible spectrum. In this respect neon is unique.

III. *Emissivity of Different Parts of an Acetylene Flame.*—Previously it has been shown that in the spectral energy curve of an acetylene flame viewed flatwise the max. emission at 1·25 μ is twice the height of the maximum at 4·35 μ; and that for the flame viewed edgewise the ratio is 5·5. In the visible spectrum the spectral energy curves of the flame viewed flatwise and edgewise were found to be superposable as is to be expected, for the colour of the flame appears to be independent of the thickness of the radiating layer. The relative intensities of the two maxima found in different regions of the acetylene flame (carbon particles and $CO_2$) were investigated. A flat and cylindrical flame were observed. In the former the carbon particles have their max. emission 2 cm. above the base, while the $CO_2$ emission continues very strong several cm. above the luminous flame. On examining the radiation from the cylindrical flame it was observed that at the base where combustion begins, but where the flame is almost non-luminous, the $CO_2$

[CO ?] already emits a considerable amount of energy. The carbon particles emit but little in the hazy region 2 cm. above the base. The $CO_2$ emission continues strong for some distance above the luminous part of the flame.

IV. *Variation of Emissivity with Thickness of the Radiating Layer—Oxides.*—The glowers used in the experiments were squirted and baked by the Westinghouse Nernst Lamp Co. and were seasoned by operating them at a high temperature for 5 or 6 hours. The generator (rotary converter) was operated on a storage battery to ensure a constant voltage. Alternating current was used so that no transference of Pt from the terminals into the glowers occurred. Experiments were made on the shape of the spectral energy curves as modified by the change in thickness of the radiating layer. This gives the loss in efficiency resulting from the preponderating increase in emission in the infra-red spectrum. The results show that for the thin glowers the spectral energy curves superpose over practically the whole length of the curve. The increase in the emissivity extending from 1·5 μ to 6 μ is very marked in the curves obtained. In order to obtain the same emissivity in the visible spectrum the thickest filament radiates 18·4 per cent. more infra-red energy than obtains in the thinnest filament. The commercial alternating-current glower is a hollow cylinder which is more efficient than a solid glower of the same diam. To manufacturers it is well known that the very thin glowers are the most efficient. The data previously given on the Welsbach mantle and those given in the present paper on the emissivity of various solid glowers show why this is the case. The thicker the glower the more nearly its radiation approaches that of a black body. For the thinnest glower the max. emission lies at about $\lambda_{\text{max.}} = 1{\cdot}25\,\mu$, and for the thickest filament the max. emission is at about $\lambda_{\text{max.}} = 1{\cdot}32\,\mu$, although it is at the same emissivity in the visible. The data given confirm the previous conclusions that the radiation constant, $a$, of the Nernst glower varies with the thickness of the radiating layer. In the paper the results of experiments are also given on: V. *Radiation from a uniformly heated cavity and from its enclosing walls*, and on: VI. *Standard spectral energy curves.* These are exhibited in tables and curves. A note is given on *Light-filters which absorb all the infra-red.* The results obtained may be summarised by stating that the method of obtaining monochromatic radiation by means of filters is very inefficient when concentrated solutions must be employed. Thus the 3 per cent. solution transmits 58 per cent. and the 3·5 per cent. solution transmits only 55 per cent. at 0·589 μ, the transmission being much higher in the blue and in the green. *The transmission of prism material* was also investigated. A plate of quartz 1·3 cm. in thickness was found to increase rapidly in opacity beyond 1·2 μ; so that it is an unsuitable material for spectral energy work at wave-lengths above this. The same is true of crown glass. A sample of deep green fluorite showed numerous absorption bands. J. J. S.

209. *Efficiency of Selenium as a Detector of Light.* **E. E. Fournier d'Albe.** (Roy. Soc., Proc. Ser. A. 89. pp. 75–90, Aug. 19, 1913.)—Investigation was made as to the limits up to which minute quantities of light and minute variations of its intensity may be discovered by means of selenium. Two actions of light may be used: (1) A change in the conductivity of Se, and (2) the generation of an e.m.f. in a voltaic cell in which Se is an electrode. The efficiency of an apparatus for the detection of light is the ratio of the amount of measurable effect it indicates to the amount of light received by the apparatus. The amount of light available is best stated in terms of the

*lumen.* Se "cells," properly so called, are electrolytic cells in which illuminated Se forms one of the electrodes and generates an e.m.f. Their efficiency is the e.m.f. in volts generated per lumen when the illumination is 1 lux (*i.e.* 1 candle-metre); the lumen being the amount of light falling on 1 sq. m. distant 1 m. from a source of 1 c.p. Se "cells" in which the action due to light is a change in resistance are more properly termed Se "bridges," and the "galvanometric efficiency" may be defined as the increase of conductivity produced in them by unit flux of light. Stebbins has recently studied the light curve of Algol by means of a selenium bridge. The following conditions are proposed for determining the normal galvanometric efficiency of a selenium bridge: (*a*) Quality of light: complete radiation from a standard pentane lamp; (*b*) Illumination: 1 lux; (*c*) Voltage: 1 volt; (*d*) Temperature: 15° C.; (*e*) History: alternate light and darkness for one minute each until steady state is attained; (*f*) Measurement: readings for successive minutes during recovery. Evaluation of the "normal galvanometric efficiency" in micromhos per lumen, in this case equivalent to microamps. per lumen, or microamps. per sq. cm. of sensitive surface, divided by 0·0001. After a preliminary experiment to test the efficiency of Se as a detector of small fluxes of light, observations were made with a Dolezalek quadrant electrometer. The galvanometric efficiency was of the order of 800 micromhos per lumen. The best results were got with a Kelvin differential galvanometer. Comparisons were made with a potassium photoelectric cell and with the human eye. In testing minute quantities of light the minimum illumination reached was 10 microlux. The law of light action was investigated and was found to be a square-root law down to the feeblest illuminations. The theoretical limit of light action discoverable by means of present-day methods and apparatus was calculated, and shown to be very far beyond the power of the eye when Se is used. Thus there is given a means of deciding the question of the discrete structure of radiant energy (theory of quanta). The author shows theoretically and experimentally that Se apparatus is capable of discriminating differences and variations of luminosity quite inappreciable by the eye. J. J. S.

210. *Correcting Colour Sensitiveness of Photographic Plates.* **H. Morris-Airey** and **S. H. Long.** (Univ. of Durham Phil. Soc., Proc. 5. pp. 119–120, 1912–1913.)—A method is described for equalising the photographic action of the various spectral colours on colour-sensitised plates, as even the best of these do not show an equal action throughout the range from red to violet. To some extent this may be done by the introduction of carefully selected colour-filters, but it is thought that none of these compensate the plates sufficiently for absorption spectra investigations. The author uses a screen prepared so that its transparency is graded to reduce the intensity at those parts of the plate where the most active wave-lengths are being impressed. Such a screen may be produced by exposing a plate, of the same make as the one to be corrected, to the spectrum of the light which is to be used for the source in the absorption spectra work. The negative thus produced is placed in juxtaposition with the subsequent plates used, and can be adjusted so as to give uniform action. C. P. B.

211. *Density in Dry Plates and Photographic Photometry.* **A. Callier.** (Photographic Journ. 53. pp. 242–257, Nov., 1913. 16th Traill Taylor Memorial Lecture.)—A study of the want of uniformity of the resultant density in plates exposed to uniformly lighted surface; unreliability of stand

development; causes of want of homogeneity in the plates. A simple method for spectrophotometry in the ultra-violet as well as with visible rays. A new $NiCl_2$ absorption standard. A. D.

212. *Physical Chemistry of Photographic Development.* **C. E. K. Mees.** (Amer. Chem. Soc., Journ. 35. pp. 1727–1732, Nov., 1913.)—The author discusses, from the physico-chemical point of view, the constitution of the photographic emulsion, the effect of light upon that emulsion, the chemical nature of the reducing agent or developer employed, and equilibrium in development. T. H. P.

213. *Electrochemistry of Light.* X. **W. D. Bancroft.** (Journ. Phys. Chem. 17. pp. 596–602, Oct., 1913. From a paper read before the 8th Internat. Congress of Applied Chemistry, New York, 1912.)—Further consideration of this subject [see Abstract No. 310 (1913)] leads the author to the following conclusions:—Although it is correct to say that only those rays that are absorbed produce chemical action, it is incorrect to add that some absorbed rays have no tendency to produce chemical action. The statement that light acts like a voltaic cell is not adequate to account for all the facts, although it has proved an admirable working hypothesis up to a certain point. The most satisfactory formulation of the chemical action of light is that all radiations which are absorbed by a substance tend to eliminate that substance; whether any reaction occurs and, if so, what are the products, are matters for chemical investigation. One and the same substance may react in different ways when subjected to the influence of different radiations. No theory has yet been advanced which allows of the prediction of the relative efficiencies of lights of different wave-lengths. T. H. P.

214. *Light-energy for Photographic Latent Image.* **P. G. Nutting.** (Nature, 92. p. 293, Nov. 6, 1913.)—Consider an exposure sufficient to produce a deposit of unit density, that is, one which will transmit but one-tenth of the incident light. A negative has unit density when the silver deposit is 10 mgm. per dm.$^2$, or 0·1 mgm. per cm.$^2$. This amount of silver represents roughly $10^{17}$ molecules, or $10^7$ grains 3 $\mu$ in diam. Now the amount of light-energy required to produce an exposure giving unit density is of the order of $10^{-7}$ watt-sec. (erg) per cm.$^2$; and therefore $10^{-14}$ erg per grain. The simplest assumption to be made is that one electron per grain is detached from one molecule; such a liberation would require $5 \times 10^{-12}$ erg, or less—a quantity consistent with that calculated above from the known exposure and mass of silver. E. H. B.

215. *Optic Properties of a Liquid Mixture.* **A. Cotton, H. Mouton,** and **P. Drapier.** (Comptes Rendus, 157. pp. 1063–1065, Dec. 1, 1913.)—An account of experiments relating to theory of molecular symmetry previously given by Cotton [see Abstract No. 399 (1913)]. The experiments have been carried out with mixtures of finely powdered crystallised calcium benzoate in aniline. The results show that the method of studying the symmetry of the molecules indicated by Cotton is applicable to liquid mixtures containing ultramicroscopic particles. To complete the study a much larger electromagnet would be required than the one used, which gave a field of 4000 gauss. A. W.

216. *Reality of the Æther.* **G. Sagnac.** (Comptes Rendus, 157. pp. 1410–1413, Dec. 22, 1913.)—In a previous paper [see Abstract No. 65 (1914)] the

author has shown that an interferograph whose circuit surrounds a certain area, and which turns in the plane of the circuit, registers its motion with respect to the æther of space. Experiments are here described which show that in the surrounding space the light is propagated with a velocity independent of the motion of the luminous source and of the optic system. This property of space characterises experimentally the luminous æther, and the experiments thus tend to prove the reality of the æther. A. W.

217. *Optical Resonance. Damping of Luminous Vibrators.* **L. Dunoyer.** (Comptes Rendus, 157. pp. 1068–1070, Dec. 1, 1913. Le Radium, 10. pp. 400–402, Dec., 1913.)—In a previous paper [see Abstract No. 780 (1911)] the author has shown that it is possible to cause to pass out into an evacuated chamber a flux of molecules all having practically parallel velocities due to the thermal agitation of an ordinary gas. This flux is not visible of itself, but by means of the phenomenon of very pure optical resonance exhibited by the gaseous molecules of sodium when they are excited by the light of the Na D-lines, it has been found possible to render visible, all along its path, the beam of molecular rays. A narrow tube projects radially into a small bulb which can be highly exhausted. On heating the lower end of the tube, which contains a little pure Na, to about 400° C., the rectilinear flux of particles is obtained from the upper end of the tube. The rays are rendered visible by light from a flame fed with a small amount of sodium. The flame is surrounded by a metallic chimney having an opening in the side, an image of which is projected so as to coincide with the path of the rays from the end of the tube. For this purpose a lens system is employed free from spherical aberration. The path of the rays is then easily observed, its boundaries sharply cut off from the general obscurity of the rest of the space in the bulb. The luminosity of the beam persists without appreciable modification for a certain time (about an hour), at the end of which the vapour commences to fill the bulb, as is evidenced by the general luminescence, more feeble than that of the principal beam. If the illumination is confined to a narrow horizontal layer by reducing the opening in the flame chimney to a width of but a few mm., the beam is luminous only in this narrow portion, and the upper and lower boundaries of the luminous portion are at first as sharply defined as the sides. This shows that the molecular resonators only travel an extremely short path, after leaving the space where they are subject to the exciting light, before they cease to vibrate. This result is quite in agreement with the value indicated by Drude as probable for the coefficient of damping of the centres of emission. A. W.

218. *Velocity of Light and Carnot's Principle.* **E. Guillaume.** (Archives des Sciences, 36. pp. 401–404, Nov., 1913. Comptes Rendus, 157. pp. 1138–1140, Dec. 8, 1913.)—Discusses the emission theory of W. Ritz [see Abstract No. 836 (1908)] by taking the special case of a luminous disc which is in vibration along its axis, and attributing an inertia to the luminous corpuscles. It is admitted that the velocity of light ($c$) may be a function of the velocity of the source ($v$) at the time of emission, viz. $c = f(v) = c_0 + av + \beta v^2 + \dots$.
E. H. B.

219. *Shadows.* **H. Paschen.** (Zeitschr. wiss. Phot. 12. pp. 409–456, Oct., 1913.)—A theoretical and experimental investigation of certain cases where umbra or penumbra are near to or overlapping one another.
A. W.

220. *Ether Radiation.* **A. v. Schütz.** (Ann. d. Natur and Kulturphilosoph. 12. pp. 187–205, 1913.)—An endeavour to depict without mathematical analysis a theory of ether radiation applying to electrons, magnets, induction, and light. E. H. B.

221. *The Photochemical Equivalent.* **E. C. C. Baly.** (Phys. Zeitschr. 14. pp. 893–896, Sept. 15, 1913.)—When a compound constantly absorbs light of definite colour, the energy so absorbed goes to "open" the electromagnetic fields of the atoms. But this process must be attended by damping, as otherwise the substance would after some time become diactinic. The fields are probably also opened by energy absorbed from the solvent. This is notably the case for the complex aromatic nitro-compounds such as trinitrobenzol, trinitroanisol, and picric acid when dissolved in basic solvents. There are always three stages, consuming equal energies, although the solvents used may be different. This is in accordance with the quanta theory. The action of the solvent accounts for the small value of the photochemical equivalent found by Henri and Wurmser. The Planck-Einstein energy quantum can only be found when the solvent is infinitesimal, as in the transformation of oxygen into ozone. E. E. F.

222. *Resonance Radiation of Mercury-vapour.* **A. v. Malinowski.** (Phys. Zeitschr. 14. pp. 884–887, Sept. 15, 1913.)—Studies the effect of a magnetic field on the emission and absorption of the resonance radiation of mercury-vapour discovered by Wood [Abstract No. 1182 (1912)]. The author used a "resonance lamp," consisting of two plates of crystalline quartz placed normally to each other against a brass box containing a drop of mercury. A somewhat similar arrangement, or a brass tube closed at both ends with fluorspar plates, was used as an absorption vessel. Both the resonance lamp and the absorption vessel could be placed in fields up to 6000 gauss. As the field increases both the emission and absorption undergo periodical fluctuations, which were revealed by a photoelectric cell. The author concludes that the resonance line 2536·7 Å. is not simple, but consists of several lines ranging over an interval of 0·04 Å. but not resolvable spectroscopically. E. E. F.

223. *Polarisation of the Light of Resonance Spectra.* **R. W. Wood.** (Phil. Mag. 26. pp. 846–848, Nov., 1913. Phys. Zeitschr. 14. pp. 1200–1201, Dec. 1, 1913.)—One of the most remarkable and important phenomena observed in connection with resonance spectra is the strong polarisation of the light even when the exciting light is unpolarised. This fact has previously been noticed [see Abstract No. 42 (1912)]. The observations have now been repeated with improved apparatus, and photographs are reproduced showing the fringes obtained by making use of a Fresnel quartz double prism of right- and left-handed rotatory power (such as is used in the study of the magnetic rotation of absorbing vapours). This was found to give fringes somewhat more distinct than the Savart plate previously used. The method of obtaining the fringes is explained. It was found that the percentage of polarisation had practically the same value in all of the lines, including the exciting or resonance radiation line. The percentage of polarisation is not nearly as high as is the case with the vapours of sodium and potassium, for which the author has observed 30 % of polarisation with the exciting light polarised. The fact that the polarisation is the same for all of the lines of the resonance spectrum seems to prove that the numerous vibrations giving rise to lines of

the resonance spectrum are set up within the atom or molecule by the vibration of the electron which responds to the monochromatic exciting light; in other words, it does not result from anything like dissociation and recombination. A. W.

**224.** *Resonance Spectra of Iodine under High Dispersion.* **R. W. Wood.** (Phil. Mag. 26. pp. 828–846, Nov., 1913. Phys. Zeitschr. 14. pp. 1189–1200, Dec. 1, 1913.)—A continuation of previous work [see Abstract No. 801 (1913)]. In the present work the exciting light was varied by altering the temperature of the lamp and the voltage drop across its terminals. Improvements in the method of utilising the exciting light made it possible to photograph the resonance spectra in the fourth-order spectrum with a large plane grating and a lens of 2 m. focal length, so that good photographs can be obtained much more quickly than before. Many photographs are reproduced, and the experiments throw much new light on the genesis of resonance spectra. A brief abstract cannot be given. A. W.

**225.** *Spectra of Helium and Hydrogen.* **E. J. Evans.** (Nature, 92. p. 5, Sept. 4, 1913.)—With reference to the new series of lines observed by Fowler and theoretically investigated by Bohr, the analysis suggests that the two principal series and the Sharp series are given by helium, and it should be possible to obtain the diffuse series from He containing no hydrogen when the Sharp series appears. Experiments by the author on a helium tube showing no trace of hydrogen gave the λ4686 line strong in the capillary and faint in the bulb, the pressure being from 0·35 to 1·00 mm. **A. Fowler.** (Nature, 92. pp. 95–96, Sept. 25, 1913.)—Fowler points out that while the 4686 line may be due to He, as suggested by Evans, it must not be hastily concluded that it is not due to hydrogen. Perhaps it may be a case of mutual action of one gas on another, as, for example, the Ritz series of infra-red hydrogen lines was found by Paschen to be brighter in a mixture of H and He than in H alone. Apart from this, the author finds it difficult to believe that the close agreement of one set of lines with the principal series calculated for hydrogen by Rydberg is merely accidental. He regards Bohr's theory as giving no better agreement than that of Rydberg. C. P. B.

**226.** *Spectra of Helium and Hydrogen.* **N. Bohr.** (Nature, 92. pp. 231–233, Oct, 23, 1913.)—From a theory of spectra based on Rutherford's theory of the structure of atoms, and Planck's theory of black radiation, the author has been led to the conclusion that the new lines observed by Fowler are not due to hydrogen, but that all the lines are due to He and form a secondary helium spectrum exactly analogous to the hydrogen spectrum [see preceding Abstracts]. The author justifies his method of uniting the two series in a single formula by showing the values given for the theoretical and observed lengths of the lines considered. **A. Fowler** replies admitting that in the exact form of the equation given by Bohr there is close agreement between the theoretical and observed values. The corrected Bohr formula leads to the further important result that alternate members of the ζ Puppis series cannot be superposed on the Balmer Hydrogen series as at first appeared. Bohr's theory has not yet been shown capable of explaining the ordinary series of He lines. C. P. B.

**227.** *Variability of Absorption Spectra.* **G. H. Livens.** (Phys. Zeitschr. 14. pp. 841–844, Sept. 1, and pp. 1050–1052, Nov. 1, 1913.)—Investigates theoretically the factors which determine the absorption spectrum of a solution [see Abstracts Nos. 168, 1276 (1913)] on the basis of Lorentz's electronic theory, and obtains a more general expression than either Planck or Havelock. In the second article the author discusses the relation of his theory to experimental data, without, however, attempting a definite proof. Shows that in general the situation of the absorption maximum is gradually displaced towards greater wave-lengths when the density of absorbing molecules becomes greater. The amount of displacement is primarily a function of the electrons concerned in the absorption, but also depends upon the active electrons. Beer's law is an approximation for smaller densities. It is not correct to assume that no atom can influence the oscillations proceeding in another atom without actually combining with it. E. E. F.

228. *Electric Conditions for the Change from the Arc- to the Spark-spectrum.* **P. Ludewig.** (Ann. d. Physik, 42. 3. pp. 643–664, Oct. 16, 1913. Extract from Freiberg Habilitationsschrift.)—La Rosa has shown [see Abstract No. 1216 (1909)] that in the light from the singing arc there is a change from the arc- to the spark-spectrum according to the relative magnitudes of the self-induction and capacity in the oscillating circuit. Wagner has further investigated the subject. The research here described shows that the spark-spectrum is not necessarily associated with the existence either of a high potential or of electric oscillations. The spark-spectrum arises when the current curve consists of sudden jumps, with sufficiently long pauses lying between. The duration of the impulsive currents must be smaller than $10^{-4}$ sec. Between the spark-spectrum and the arc-spectrum there exists a continuous series of intermediate spectra, and by increasing the duration of the above-mentioned current impulses the spectrum approaches nearer and nearer to the arc-spectrum. It thus appears that the arc- and spark-spectra take a special place in this series of spectra only because they happen to be, in our present knowledge, the end members of the series. It is quite possible that under suitable experimental conditions the series of spectra may be extended. A. W

229. *Sodium Absorption Lines.* **C. Füchtbauer** and **C. Schell.** (Deutsch. Phys. Gesell., Verh. 15. 20. pp. 974–981, Oct. 30, 1913. Paper read before the 85. Deutsch. Naturforscherversamml., Sept., 1913. Phys. Zeitschr. 14. pp. 1164–1168, Nov. 15, 1913.)—The temperature and pressure were kept constant, and the absorption lines widened by the addition of nitrogen. The following results were obtained :—The sodium D lines both give the same value of the damping parameter. In this case the ratio of numbers of electrons per $cm.^3$ is the same as the ratio of the absorption coefficients, which the author finds to be 2 : 1. This result agrees with Gouy's calculated from emission of flames and Roschdestwensky's from dispersion. The ratio of the number of optical perturbations to the number of collisions is 18 : 1, *i.e.* about $\frac{1}{10}$ as great as that calculated by Lorentz from Hallo's experiments. The number of vibrating electrons is of the same order as the number of metallic atoms.

J. M.

230. *Cæsium Absorption Lines.* **C. Füchtbauer** and **W. Hofmann.** (Deutsch. Phys. Gesell., Verh. 15. 20. pp. 982–991, Oct. 30, 1913. Paper read before the 85. Deutsch. Naturforscherversamml., Sept., 1913. Phys. Zeitschr. 14. pp. 1168–1172, Nov. 15, 1913.)—A continuation of Füchtbauer and Schell's research [see preceding Abstract], the following being the conclusions arrived

at :—(*a*) By using nitrogen filling for tubes the exact condition for absorption may be reproduced. (*b*) The "half-value-interval" is proportional to pressure as Lorentz's theory demands. (*c*) Maximum absorption is inversely proportional to pressure. Therefore the number of vibrating particles is independent of pressure of neutral gas filling. (*d*) Ratio of two lines of doublet decreases with the order. Values are whole numbers and identical for different alkali metals in the same order. (*e*) Half-value intervals for doublet lines are nearly equal. (*f*) The number of perturbations calculated from half-value interval is from 20 to 82 times the number of collisions calculated from the gas theory. Both numbers are of same order in the case of series lines and of bands. (*g*) The number of electrons and of metallic atoms are of the same order for lines of first pair of series. Therefore carriers of primary series lines of alkali metals appear to be the neutral molecules. (*h*) The intensity is unsymmetrical, the absorption falling off more quickly on the violet than on the red side. J. M.

231. *Distribution of Energy in the Spectra of Gases.* **H. L. P. Jolly.** (Phil. Mag. 26. pp. 801–827, Nov., 1913.)—The object of the investigations described was, in the first instance, to determine quantitatively the manner in which the energy distribution among the lines of a bright-line spectrum varied when the intensity of excitation was changed. The results of the investigations may be summarised as follows :—(i) If the current in a discharge tube be small, the radiation from it is proportional to the current-density, both for the whole spectrum and for any portion of it. (ii) In heavy discharges such as that produced by a large condenser in parallel with the discharge tube, there is strong evidence that the energy shifts towards the longer wave-lengths when the current-density increases. Whether the energy of any portion of the spectrum increases at a rate greater or smaller than the current has not been determined, owing to the difficulties in the way of measuring these currents. (iii) When the pressure at which a condensed discharge is sent through the tube is increased, the energy shifts towards the longer wave-lengths. A continuous spectrum makes its appearance in these discharges, and becomes more marked the higher the pressure. A. W.

232. *Dispersion of Light in Gases in Ultra-violet Region.* **J. Koch.** (Ark. för Mat. Astron. och Fysik, Stockholm, 8. No. 20. pp. 1–25, 1913.)—The investigation deals with the dispersion in the ultra-violet region of hydrogen and air. A Jamin interferential refractometer was used, the interference fringes being directed to the slit of a quartz spectrograph by means of a mirror. A high-pressure quartz mercury lamp was used as the source of light. The spectrum was photographed for different pressures in one of two glass tubes containing the gas between the quartz parallelopipeds of the refractometer, the spectral lines appearing crossed by oblique interference bands. The results are discussed with reference to the dispersion theory developed by Lorentz, Planck, Drude, etc. [See Abstract No. 8241 (1904).] A. W.

233. *Dispersion of Light in Gases in Ultra-violet Region.* **J. Koch.** (Ark. för Mat. Astron. och Fysik, Stockholm, 9. No. 6. pp. 1–11, 1913.)—In a previous paper the author has considered the dispersion of light in hydrogen and air in the ultra-violet region [see preceding Abstract]. The present paper deals with nitrogen and helium. A. W.

**234.** *Spectrum of Active Nitrogen.* **E. P. Lewis.** (Phil. Mag. 25. pp. 826–832, June, 1913.)—The only invariably characteristic part of the afterglow spectrum are the bands with heads at 6822, 5854, 5442, and 5058, belonging to the "first positive" group. In the author's experiments the afterglow continuously increased in intensity as the proportion of oxygen was reduced, but he doubts whether in any case the nitrogen was completely freed from oxygen or nitric oxide, and the origin of the afterglow still seems an open question. With a sufficiently strong discharge it might possibly be produced with large quantities of oxygen present. No trace of Strutt and Fowler's "fourth group of positive bands" was found on photographs of the spectrum of N freed as far as possible from oxygen, though they appear when there is a slight admixture of oxygen. The author believes that the second group of bands are due to the dissociation produced by the discharge, and the third and $\beta$ groups are associated with the afterglow and the period of recombination.

E. E. F.

**235.** *Metallic Spectra with the Tube-arc.* **A. S. King.** (Mount Wilson Solar Observatory Contributions, No. 73. Nature, 92. p. 302, Nov. 6, 1913. Abstract.)—In the course of an investigation of electric-furnace spectra by means of a resistance tube, certain interesting variations in intensity of different types of lines were examined, tables of results and typical reproductions of some of the spectra being given in the paper. C. P. B.

**236.** *Mercury Spectrum in Schumann Region.* **T. Lyman.** (Astrophys. Journ. 38. pp. 282–291, Oct., 1913.)—The mercury spectrum now being used for so many investigations rendered it advisable to obtain a more complete record of its constitution, which previous to the present work did not extend beyond about λ1850 [Abstracts Nos. 854, 1531 (1912)]. Lines predicted by Paschen at λ1849·6 and λ1402·5 have been detected in the mercury arc spectrum; Paschen's third line at λ1268·9 is within the limits of the photographs, but has not yet been found. A table is given showing the wave-lengths and relative intensities of 86 lines extending from λ1269·7 to λ1875·7, and sketches are given of the types of mercury lamps employed. C. P. B.

**237.** *Band Spectra and their Modifications.* **H. Deslandres** and **L. d'Azambuja.** (Comptes Rendus, 157. pp. 671–678, Oct. 27, 1913.)—A *résumé* is given of the progress of knowledge concerning the structure of band spectra rendered possible by the gradual improvement and increase in power of the spectrographs employed for observation from 1885 to 1911. Illustrations are given showing some of the chief advances as found in the bands of the spectrum of nitrogen. (*Erratum*, Ibid. p. 118, Nov. 3, 1913).

C. P. B.

**238.** *Effect of Electric Field on Spectrum Lines.* **J. Stark.** (Preuss. Akad. Wiss. Berlin, Ber. 40. pp. 932–946, 1913.)—A cylindrical tube was furnished with a flat kathode K perpendicular to the axis of the tube; the kathode was supported at three points and had a number of perforations 1 mm. wide. Just below this was fixed an auxiliary electrode H; this was unperforated, and in some experiments was 2·6 mm., in others 1·1 mm. from the kathode. The anode A was sealed into the other end of the tube. A and K were connected to a large induction coil. H and K were connected to a steady current source, H to the negative, K to the positive pole. The gas pressure was reduced till the length of the dark space was 5 to 10 cm. For the constant p.d. between H and K a dynamo (4500 volts) was used, with a battery of accumulators (8800 volts). Sometimes the two were connected in series, at other times the battery alone was used. With this arrangement the effect of the electric field on various spectrum lines was investigated. Photographs were taken, the exposures varying from 25 mins. to 8 hours. Observations of the transversal effect with the hydrogen lines $H_\beta$, $H_\gamma$ show that they are each split up into five components by the action of the electric field, the oscillations of the three middle components being parallel, and the two outer ones perpendicular, to the direction of the electric field. The centre component lies very near to the position of the original line, apparently being slightly displaced towards the side of longer wave-lengths. The potential gradient in these experiments was 13,000 volts/cm. In helium the lines λ4472 and λ4026 of the first subordinate series are split up into three components with oscillations parallel, and three with oscillations perpendicular to the direction of the field. Diagrams are given for these and for other lines dealt with. Investigations of the dependence of the effect on the field strength show that to a first approximation the dispersion is proportional to the first power of the field strength. The experiments show that it is probable that the members of the same series of spectrum lines are affected in the same manner by the electric field, as regards the number, oscillation directions and intensity ratios of their components. The splitting-up of a line into components appears to be the only thing common to the new effect and the Zeeman-effect; in other respects they differ. The electric dispersions for different series lines differ from one another in order of magnitude; the magnetic dispersion is for all series lines of the same order of magnitude. The distance apart of the Zeeman components of a line in a given series is proportional to the square of its wave-length; the distance of its components in an electric field, at all events for numerous lines, increases with decreasing wave-length. Homologous series lines of different elements show in numerous cases the same Zeeman-effect, with certain reservations; in the new effect the lines of H and He exhibit quite different behaviour. Further investigation of the phenomenon should lead to a better understanding of the dynamics of the atom. A. W.

239. *Ultra-violet Lines.* **R. Wolff.** (Ann. d. Physik, 42. 4. pp. 825–839, Nov. 4, 1913.)—The author has examined the arc spectra of zinc, cadmium, and mercury to the transparency limit of fluorspar, discovering the primary series and the combination series calculated by Paschen [see Abstracts Nos. 1486 (1911), 985 (1913)]. Taking these series lines as standards he has fixed the position of several uncertain mercury and hydrogen lines and measured new carbon and silicon lines. J. M.

240. *Zeeman-effect.* **R. Fortrat.** (Comptes Rendus, 157. pp. 636–639, Oct. 20, 1913.)—A further examination of the sodium doublet λ = 2853 [Abstract No. 1440 (1913)] in a field of 49,400 gauss, obtained with a Weiss ferro-cobalt electromagnet [Abstract No. 1511 (1913)]. The author finds his results in close agreement with those calculated from Voigt's theory if all the lines are displaced 0·03 Å. [See Abstract No. 1826 (1913).] J. M.

241. *Production of Luminescence by Kathode and Canal Rays at Liquid-air Temperature.* **E. Ohlon.** (Ark. för Mat. Astron. och Fysik, Stockholm, 8. No. 22. pp. 1–20, 1913.)—A large number of minerals and metallic salts are examined with regard to their properties of emitting luminescence under the action of both kathode and canal rays. The observations with the

minerals were of a preliminary character only and revealed the fact that the intensity of the luminescence produced by these agencies was much greater at low than at ordinary temperatures. Consequently the observations with the metallic salts were made at the temperature of liquid air. With the salts of the more electropositive metals, viz. Li, Na, K, Ca, Ba, Sr, and Mg, two types of luminescence are to be observed. When the salts are first subjected to the rays a bluish luminosity is seen which, however, diminishes in intensity, in some cases rapidly, giving place to a second luminescence which varies in colour according to the salt. With the salts of Zn, Cd, Pb, Hg, Fe, Cu, and Mn, luminescence of the second type only is to be observed. The author concludes, after comparing his results with those of Goldstein [see Abstract No. 717 (1912)] and others, that the first type of luminescence, which is similar for different materials, is caused by the escape of electrons, since it occurs with salts of the photoelectric metals; the second type is due to the escape of the metal atoms which have previously lost their valency electrons, for in some instances when canal rays are the exciting agency the luminosity gives line spectra characteristic of the metal. The spectra, however, generally consist of bands. The experimental results are given in tabular form and include observations on the phosphorescence and thermoluminescence of the substances. F. J. H.

**242.** *Fluorescence of Sulphur, Selenium, and Tellurium Vapour.* **W. Steubing.** (Phys. Zeitschr. 14. pp. 887–893, Sept. 15, 1913.)—The sixth vertical column of the periodic system shows 4 elements whose vapours are capable of fluorescence: O, S, Se, and Te. The exciting radiation for these is below 2000 Å. in the case of oxygen, between 2500 and 3200 in the case of sulphur, above 3000 in the case of Se, and in the case of Te it lies in the most refrangible portion of the visible spectrum. The fluorescence requires vapour of definite density and temperature. Thus sulphur must be superheated to 400° to 500° C. The fluorescence spectra are discontinuous and show ill-defined groups of lines resembling bands. They are greatly weakened by the admixture of foreign gases and vapours. E. E. F.

**243.** *Photography of Röntgen-ray Spectra.* **M. de Broglie.** (Comptes Rendus, 157. pp. 924–926, Nov. 17, 1913. Deutsch. Phys. Gesell., Verh. 15. 24. pp. 1348–1349, Dec. 30, 1913.)—From the researches of Laue and Bragg we know that the Röntgen rays reflected from a face of a crystal ought, according to the generally accepted theory, to have a wave-length $\lambda$ such that $n\lambda = 2d \sin \theta$, where $n$ is a whole number, $d$ the distance of the reticular planes parallel to the plane of reflection, and $\theta$ is the complement of the angle of incidence on this plane. A crystal was mounted on the cylinder of a registering apparatus arranged to turn with an angular velocity of about 2° per hour. At the start the incident beam X is parallel to the face considered of the crystal; the angle of incidence varies regularly with the time, and the reflected beam, which turns twice as fast, sweeps across a photographic plate and gives a continuous record. If there exist in the incident beam more intense wave-lengths, corresponding to definite values of $\theta$, the reflected ray, inclined at $2\theta$ to the incident beam, will mark more intense lines on the plate. Thus a line spectrum is obtained, having the appearance of an ordinary luminous spectrum, with lines fine or diffuse, bands, etc. If the incident beam could be kept constant for the whole time of the experiment nothing further would be required, but this can only be realised in general in a rough manner when the exposure is not long. Hence it is necessary to add a second registering apparatus, giving at each instant the intensity of the incident beam. A much less sensitive emulsion is required for the photographic plate for the latter purpose. Using a crystal of rock-salt a remarkable series of fine lines and bands was obtained on a continuous ground. The complete study of these plates is not yet finished, but it appears certain that the principal lines do not correspond to the maxima noted by Bragg, Moseley, and Darwin in their ionisation measurements. This is not surprising, since the ionisation method is usually carried out with very soft tubes, while the present results were obtained with hard tubes. A. W.

**244.** *Spectrum of Röntgen Rays.* **M. de Broglie.** (Comptes Rendus, 157. pp. 1413–1416, Dec. 22, 1913.)—In a previous paper [see preceding Abstract] a method was described of obtaining the spectrum of Röntgen rays by slowly rotating a crystal, so that the angle of incidence varied continuously. The method has now been further investigated and the results show that the spectrum is characteristic of the substance used as the antikathode. Various tubes, with antikathodes of platinum or tungsten, have each regularly furnished their characteristic spectra using various crystals of fluorine, pyrites, sylvine, calcspar, and rock-salt. The latter is particularly suitable on account of the intense images which it gives. The following table is an example of the spectrum obtained, using a tungsten antikathode and an analyser of rock-salt:—

| | |
|---|---|
| Intense band, sharp towards long wave-lengths ... | 0° to about 8° 50′ |
| Less intense band ........................................ | 8° 50′ to about 9° |
| Fine line, mean intensity ............................... | 10° 25′ |
| Doublet { I intense ....................................... | 11° 55′ |
| Doublet { II mean intensity.............................. | 12° 20′ |
| Line, mean intensity ...................................... | 14° 30′ |

Debye has recently given a remarkable formula for the intensity of a diffraction maximum of a Röntgen beam of wave-length λ by a crystal at absolute temperature T. This intensity is proportional to $e^{-2\epsilon(1-\cos\delta)}$, $\delta$ being the angle between the incident and diffracted rays and $\epsilon$ being given by $\epsilon = 4\pi^2 KT/f\lambda^2$. K is a universal constant and $f$ an elastic constant of the crystal, related to what has been called the proper period of the body. But λ and $(1 - \cos\delta)$ are not independent, for $n\lambda = 2d \sin(\delta/2)$, where $d$ is the distance between the parallel planes of the plane reflector which furnishes the diffraction maximum and $n$ is the order of the spectrum. If $n = 1$, $\lambda = 2d \sin(\delta/2)$, and $2\sin^2(\delta/2) = 1 - \cos\delta = \lambda^2/2d^2$. Substituting in the expression for the intensity, it is seen that this now contains neither $\delta$ nor λ; it only depends on T for a given crystal. Hence, with the restriction as to the order of the spectrum, the effect of temperature on the intensity of a diffraction maximum does not depend on the angle $\delta$, or rather it only depends on it very indirectly through the quantity $d$. Experiments have already furnished the expected verification of a first consequence of the theory of Debye, *i.e.* the fact, sufficiently surprising at first sight, of the sharpness of diffraction maxima, which appear as independent of the temperature. The variation with temperature of the relative intensity of these maxima has been found apparently to be smaller than is indicated by Debye's formula in its original form, but the above gives some explanation of the observed differences. A. W.

245. *Energy of Röntgen Rays.* **R. T. Beatty.** (Roy. Soc., Proc. Ser. A. 89. pp. 314–327, Nov. 1, 1913.)—The experiments deal with a determination of the amount of energy which reappears as Röntgen radiation when kathode rays of given speed fall on antikathodes of different metals. A pencil of homogeneous kathode rays is sorted out by means of a magnetic field and allowed to fall on an antikathode. The resulting X-rays escape through a diaphragm with practically no absorption, and are then completely absorbed in a long ionisation chamber containing air saturated with methyl iodide. To avoid variations of the intensity of the source the ratio of the total ionisation current to the current carried by the kathode particles themselves is measured by a special null method. In this way it is found that the total ionisation produced by the X-rays in the chamber is proportional to the fourth power of the velocity of the kathode rays producing them, *i.e.* $X = 0{\cdot}58\,A\beta^4$, where X is the total ionisation current ($4\pi$) due to the X-rays per unit of kathode-ray current, A the atomic weight of the radiator and $\beta$ is the ratio of the velocity of the kathode rays to the velocity of light. This relation only holds in cases where the characteristic radiation is not being excited. The next step is to find how much energy the X-rays possess relatively to the energy of the primary kathode rays. This is taken as equal to X/N, where N is the number of pairs of ions which would be produced by the primary kathode rays. N is assumed to be the same as in air and is calculated from Glasson's results for the number of ions per cm. of path produced by kathode rays, and Whiddington's results on the rate of loss of energy of kathode particles. In this way X/N is found to be equal to $2{\cdot}54 \times 10^{-4} A\beta^2$. For example, if a Pt radiator be excited by kathode rays of speed $10^{10}$ cm./sec., $A = 195$, $\beta = \frac{1}{3}$ and $X/N = 5{\cdot}51 \times 10^{-3}$. This is the energy of the "independent X-rays"; the characteristic rays which will be excited in this example will increase the total energy emitted. E. M.

246. *Experiments on the Reflection of X-rays.* **R. W. A. Salmond.** (Röntgen Soc., Journ. 9. pp. 98–102; Discussion, pp. 102–105, Oct., 1913.)—The paper gives details of interesting photographs obtained by allowing a beam of X-rays to fall on mica and a few other crystals. E. M.

247. *Quantitative Determination of Radium Emanation.* **L. Flamm** and **H. Mache.** (Akad. Wiss. Wien, Ber. 122. 2a. pp. 535–542, March, 1913. Phys. Zeitschr. 14. pp. 1122–1125, Nov. 15, 1913. Paper read before the 85. Naturforscherversamml., Wien, Sept., 1913.)—Using guard-ring plate electrodes the authors find that the ionisation current for pure emanation is $2{\cdot}75 \times 10^6$ e.s. units per curie. To obtain this value [see Abstract No. 75 (1913)] corrections have to be applied for initial recombination in the $\alpha$-ray ionisation columns. The above number agrees almost exactly with that calculated from the number of $\alpha$-particles emitted per sec. and the number of ions produced by each $\alpha$-particle. E. M.

248. *Determination of Radium in Radio-active Substances.* **A. L. Fletcher.** (Phil. Mag. 26. pp. 674–677, Oct., 1913.)—A small splintered and weighed fragment of the mineral or salt under investigation is placed in a hollow in a carbon rod. A current is sent through the carbon so as to raise the temperature to about 2500° C. In about 20 seconds this completely de-emanates the specimen and the emanation can be pumped off into an electroscope. Results are given which show that the method is very reliable. In one of the experiments it is shown that a temperature of 900° C. is necessary to completely de-emanate pitchblende in 1 minute. E. M.

**249.** *Distribution of the Active Deposit of Radium in an Electric Field.* **E. M. Wellisch.** (Amer. Journ. Sci. 36. pp. 315–327, Oct., 1913. Phil. Mag. 26. pp. 623–635, Oct., 1913.)—A continuation of the experiments described in Abstract No. 1039 (1912). It is shown that when the emanation is mixed with any gas there appears to be a definite limit to the fraction of the active deposit which settles on the kathode. The limit is independent of the pressure of gas, provided it is high enough to prevent the deposit particles from recoiling on to the walls of the vessel; it is in general dependent on the nature of the gas. It is shown that even in air which has been thoroughly dried, the recombination between the positively-charged deposit particles and negative ions is greater than the recombination between ordinary positive and negative ions. Thus as it moves through the gas the recoil atom of the active deposit (RaA) produces a large number of ions, and in the act of ionisation it is possible that the recoil atom may lose its positive charge. The process is in many respects similar to that which is known to occur in the case of canal rays. In ether, the molecules of which are easily ionised, this special recombination effect is very prominent as only 90 % of the total activity can be concentrated on the kathode. E. M.

**250.** *Alpha-rays from Thick Layers.* **L. Flamm.** (Phys. Zeitschr. 14. pp. 812–815, Sept. 1, 1913.)—A method of exact integration is given for E. v. Schweidler's expression [Abstract No. 1672 (1913)] for the ionisation above thick layers of a substance emitting α-rays, and it is shown how it can be utilised by means of simple auxiliary experiments, based on the apparatus used by Bragg for studying the ionisation of argon and helium. E. E. F.

**251.** *Analysis of the β-Rays from Radium B and Radium C.* **E. Rutherford** and **H. Robinson.** (Phil. Mag. 26. pp. 717–729, Oct., 1913.)—The authors have made detailed measurements of the velocities of the homogeneous groups of β-rays emitted from RaB and RaC, the values being calculated from measurements of the deflection in known magnetic fields. The results are represented in a diagram in the original, which is, however, too large for reproduction here. In this, values of $H\rho$ and of energy ($10^{13}e$) for RaB and RaC are shown juxtaposed (where $H\rho = mv/e$; $m$, $v$, and $e$ being the mass, velocity, and charge of the β-particles and $\rho$ the radius of curvature in a magnetic field of strength H). The energy E is calculated from the Lorentz-Einstein formulæ—

$$E = m_0/e \, . \, c^2 \left[1/\sqrt{(1-\beta^2)} - 1\right] ; \; m/m_0 = (1-\beta^2)^{-\frac{1}{2}} ;$$

where $e/m = 1{\cdot}772 \times 10^7$, $c$ is the velocity of light, and $\beta = v/c$. It is found that for RaC, which is known to give only one type of γ-rays, the energies of most of the pencils of β-particles differ by an integral factor of a constant $E_1 = 0{\cdot}4284 \times 10^{13}e$. This presumably represents the energy in a single γ-ray [Abstract No. 433 (1913)]. It is also noticed that the energy of each of the pencils is nearly an integral multiple of the common difference ($E_1$). E. M.

**252.** *Scattering of α-Particles by Gases.* **E. Rutherford** and **J. M. Nuttall.** (Phil. Mag. 26. pp. 702–712, Oct., 1913.)—In the experiments a narrow pencil of α-particles was obtained by placing a thin Pt-wire coated with RaC between two thick glass plates about 15 cm. in length and 0·3 mm. apart. After traversing the space between the glass plates, which were in a chamber that could be exhausted, the α-particles passed through a mica window into an ionisation chamber where measurements could be made of their intensity. A gas was introduced into the space between the glass plates, and the number of α-particles taken from the beam by scattering into the plates was estimated.

It was shown that if $N_0$ is the number of $\alpha$-particles in the emerging beam at zero pressure and $N_p$ at pressure $p$, then $N_p = N_0 e^{-\lambda p}$, where $\lambda$ may be called the "scattering coefficient" for the particular gas under the given conditions. This equation only holds as long as the $\alpha$-particles are not appreciably altered in velocity by traversing the gas between the plates. It was shown that $\lambda \propto 1/v^4$, where $v$ is the initial velocity of the $\alpha$-particles, and from this and other considerations it is deduced that the scattering is of the "single" type, *i.e.* due to single encounters with the atoms in the gas [Abstract No. 1347 (1911)]. If the central nucleus of the atom has a charge $ne$ it is deduced that $\lambda = cn(n+1)$, where $c$ is a constant. The gases used in the experiments were air, $CH_4$, $CO_2$, $O_2$, S, $H_2$, and He, and assuming the result of Geiger and Marsden [Abstract No. 1296 (1913)] that carbon has a central charge $6e$, it is deduced that the helium atom has a central nucleus with charge $2e$, and that hydrogen has a central nucleus with charge $e$. This simple structure for H- and He-atoms has been assumed by Bohr in recent papers on the constitution of atoms, and shown to yield very promising results [see Abstracts Nos. 1930 (1913) and 15 (1914)]. E. M.

**253.** *Scattering and Absorption of the γ-Rays of Radium.* **J. A. Gray.** (Phil. Mag. 26. pp. 611–628, Oct., 1913.)—Florance has shown that the secondary or scattered γ-rays become less penetrating as the angle of scattering is increased [Abstract No. 351 (1911)]. This result has generally been explained by assuming that the primary γ-rays are heterogeneous and that the softer rays are scattered through larger angles. In the present experiments the author shows, by first absorbing soft radiations, that this is not necessarily the case, but that when γ-rays are scattered they undergo a change in quality. The change in quality is gradual and small when the angle of scattering is small. It is shown that the quality and quantity of the scattered radiation is approximately independent of the nature of the radiator. The softer the type of γ-rays the greater the percentage scattered per unit mass. A discussion is given of the bearing of the results on absorption experiments, and it is deduced that an exponential law signifies heterogeneity of the rays. In the case of X-rays scattering is in most cases so small compared with absorption that an exponential law probably signifies homogeneity. E. M.

**254.** *Reflection of γ-Rays from Crystals.* **E. Rutherford** and **E. N. da C. Andrade.** (Nature, 92. p. 267, Oct. 30, 1913.)—Rutherford and Richardson [Abstract No. 1675 (1913)] have shown that RaC emits one, and RaB emits three types of γ-radiation each of which is exponentially absorbed by Al. The present paper deals with an examination of these types of radiation by the methods developed for X-rays by W. H. and W. L. Bragg and by Moseley and Darwin, which consist in determining, either by the photographic or the electric method, the intensity of the X-rays reflected from a crystal at different angles of incidence. In the experiments the source of γ-radiation was a thin-walled "α-ray" tube containing about 100 millicuries of emanation in equilibrium with its products A, B, and C. A diverging cone of rays fell on a crystal of rock-salt, and the distribution of the reflected radiation was examined by a photographic plate placed 10 cm. from the centre of the crystal. A group of fine lines comprised between the glancing angles 8° and 10° was observed on the photographic plate. Similar results were obtained with a crystal of potassium ferrocyanide. It is hoped that in this way definite evidence will be obtained on the constitution and wave-length of each of the types of γ-radiation emitted from RaB and RaC. E. M.

**255.** *Speed of δ-Rays.* **N. Campbell.** (Phil. Mag. 26. pp. 774–775, Oct., 1913.)—It was recently shown [see Abstract No. 1677 (1913)] that theory predicted that the distribution of velocities among δ-rays from metals should be independent of the nature of the primary rays, but that it gave too small a value for the number of very slow δ-rays (under 20 volts). This discrepancy is now removed by the work of Bumstead [Phil. Mag. 26. p. 233, 1913, also Abstract No. 1677 (1913)]. Indeed there appears to be nothing in our present knowledge of the δ-rays inconsistent with the view that they represent the electrons ejected from atoms by the passage through them of charged particles in accordance with the simple theory of that action given by Thomson. E. H. B.

**256.** *Uranium $X_2$.* **K. Fajans and O. Göhring.** (Phys. Zeitschr. 14. pp. 877–884, Sept. 15, 1913.)—Uranium X consists of two successive products: $UrX_1$, with a half-period of 24·6 days, and a new short-lived product now called $UrX_2$. The latter has a half-period of decay of 1·15 mins., and its radio-active constant of disintegration is 0·0100 sec.$^{-1}$. $UrX_2$ emits only hard β-rays, identical with those of UrX (absorption coefficient in Al = 15 cm.$^{-1}$). The soft rays of UrX are attributable to $UrX_1$ (500 cm.$^{-1}$), which does not emit hard rays. These facts bear out the rule that very hard β-rays are only emitted by short-lived substances, and very soft β-rays by long-lived substances. $UrX_2$ is electrochemically nobler than $UrX_1$. Its chemical properties place it in the fifth group of the last horizontal row of the periodic system, and make tantalum its nearest congener. The revised Ur series becomes—

$$\mathrm{Ur_I} \xrightarrow{\alpha} \mathrm{UrX_1} \xrightarrow{\beta} \mathrm{UrX_2} \xrightarrow{\beta} \mathrm{Ur_{II}} \xrightarrow{\alpha} \mathrm{Io} \xrightarrow{\alpha} \mathrm{R_a}.$$

Valency 6 4 5 6 4 2 E. E. F.

**257.** *γ-Rays from the Products of the Thorium Series.* **L. Meitner and O. Hahn.** (Phys. Zeitschr. 14. pp. 873–877, Sept. 15, 1913.)—In order to furnish further data towards a study of the nature of γ-rays, the authors determine the distribution of γ-ray activity among the members of the Th series. It turns out that ThX possesses a γ-radiation whose absorption is greater than the average absorption of the γ-rays of the active deposit. In ThB a γ-radiation is found which is absorbed to the extent of 50 per cent. by 1 mm. of lead, and constitutes 22 per cent. of the total γ-radiation. If ThC emits a γ-radiation at all, its penetrating power is identical with that of ThD for all thicknesses of lead between 0 and 19 mm. [See also Abstracts Nos. 888 (1911), 1715 (1912).] E. E. F.

**258.** *Range of Recoil Atoms from Thorium C and Actinium C.* **A. B. Wood.** (Phil. Mag. 26. pp. 586–597, Oct., 1913.)—In the active deposits of actinium and thorium the recoil radiations arise from the emission of the α-particles from the C products. In the present paper the "ranges" of these recoil atoms have been determined by two methods. In the first method a small disc coated with active deposit was placed at the centre of a hemisphere in a vessel which could be exhausted. The amount of the D product received on the hemisphere was investigated for different pressures by subsequent observation of its β-ray activity. The limiting pressure ($p$) at which no D-atoms reached the hemisphere was observed, and the range R at atmospheric pressure calculated from $R = pd/760$, where $d$ is the distance from the active disc to the surrounding hemisphere. In the second method an arrangement of a wire gauze similar to Bragg's method of determining the range of α-particles was used, since it is known that a recoil atom is a very efficient ioniser [Wertenstein, Abstracts Nos. 1586 and 1848 (1912)]. In the case of actinium C the two methods gave the same results, 0·125 mm. in air and 0·55 mm. in H. In the case of ThC, however, the first method gave 0·12 mm. in air and 0·55 mm. in H, while the ionisation method gave 0·175 mm. in air and 0·74 mm. in H. The range of the α-particles of AcC is 5·4 cm., while in ThC there are two sets of α-particles emitted on different branches with ranges 4·8 cm. and 8·6 cm. The ionisation method gives the range of the recoil atom corresponding to the swiftest α-particle, and as the range of the recoil ThD is much less than the range by the ionisation method, ThD must arise by disintegration of $ThC_1$, which gives the α-particle of range only 4·8 cm. This agrees with the scheme of disintegration suggested by Marsden and Darwin [Abstract No. 1714 (1912)]. E. M.

259. *Penetrating Radiation.* **V. F. Hess.** (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1053–1077, June, 1913. Phys. Zeitschr. 14. pp. 610–617, July 15, 1913.)—The penetrating radiation found throughout the atmosphere is usually attributed to traces of RaC, but measurements with emanation apparatus show only $1·6 \times 1·9 \times 10^{-15}$ curie per $cm.^3$. which is some 20 times too little to account for the penetrating radiation observed. The latter, it is true, is increased in closed rooms by the secondary γ-rays emitted by the walls, but this increase amounts to only some 20 per cent. At heights of 1000 m. and more, at which free balloon observations of the penetrating radiation were made by Gockel and the author, there is an increase in the penetrating radiation, and since at such heights all radiation from the earth's surface is ineffective, and the amount of emanation and RaC is not likely to be greater than at the earth's surface, the author concludes that the penetrating radiation is due to some unknown radio-active substance. E. E. F.

260. *Gradient of Penetrating Radiation from the Earth.* **L. V. King.** (Phil. Mag. 26. pp. 604–611, Oct., 1913.)—The author works out the formulæ for the gradient of the ionisation due to the penetrating radiation from radium in soil, etc., both upwards into the atmosphere and downwards below the surface of the soil. Using the most recent data, curves are given to represent actual conditions. Thus at a height of 883 m. the penetrating radiation is reduced to 0·087 of its surface intensity, while at a depth of 16·7 cm. its value is 1·968 of that at the surface. The author next discusses the various experimental observations of ionisation in the atmosphere. In the case of balloons it is probable that during the ascent the potential of a balloon is several thousand volts higher than the air in its immediate neighbourhood, so that it acts as a collector for active deposit present in the atmosphere. A list of precautions is given for experiments on the measurement of the gradient of the penetrating radiation in the atmosphere. E. M.

261. *Radio-activity of the Carbonated Springs of Mt. Iduna, Sinano.* **D. Isitani.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 150–156, Oct., 1913.)—The springs in question are cold and arise from an extinct volcano. The mean amount of radium emanation per litre of water was found to be $80 \times 10^{-12}$ curie. E. M.

## HEAT.

**262.** *Absolute Thermal Conductivity of Glass.* **I. Williams.** (Phil. Mag. 26. pp. 598–604, Oct., 1913.)—A new method of measuring the thermal conductivity of glass by radial flow in a thick-walled capillary tube is described. A horizontal capillary has wide vertical glass tubes sealed to its ends. The whole is filled with mercury and placed in a vessel through which water circulates rapidly. Heat is communicated to the inside of the capillary by sending a current through the mercury, the quantities communicated to lengths $l_1$ and $l_2$ in series being obtained from the current and the p.d.'s between leads inserted in holes bored in the tube at the ends of these lengths. The difference in these two amounts is considered to give the quantity of heat conducted through the glass for a length $l_1 - l_2$, end effects being thus eliminated. The radial fall of temperature is measured with a thermo-couple having one junction in the mercury at a point between the two lengths considered and the other in the surrounding water. The author purposes using the method for measuring the temperature coefficient of thermal conductivity of glass and quartz. F. J. H.

**263.** *Volume-changes of Amalgams.* **J. Würschmidt.** (Deutsch. Phys. Gesell., Verh. 15. 20. pp. 1027–1036, Oct. 30, 1913.)—The author has continued the study of the expansion of amalgams [see Abstract No. 719 (1913)]. In the case of tin amalgams the coefficient of expansion begins to increase below the melting-point and has its max. value at the melting-point. So sharp is this that the property can be employed for determining the melting-point. In the case of zinc amalgams the max. value of the coefficient of expansion is found below the melting-point, but it was found that the coefficients of expansion depend on the past history of the amalgam. The maximum of the coefficient is caused by time changes of the volume. Bismuth amalgam, like pure Bi, shows a contraction at the melting-point, but this contraction begins far below the melting-point and reaches its first maximum at 90°. A. F.

**264.** *Specific Heats of certain Diatomic Gases.* **W. Escher.** (Ann. d. Physik, 42. 4. pp. 761–778, Nov. 4, 1913. From papers published by F. Richarz and the author at the University of Marburg.)—The earlier determinations of the specific heats of gases have been thought by Richarz to be inaccurate since they give wrong values for the mechanical equivalent of heat calculated by Mayer's method from these determinations and the ratio of specific heats. At the suggestion of Richarz, Everts, Stoll and the author have redetermined the specific heats of nitrogen, oxygen, hydrogen, and air by the method of mixtures. In the present paper the determinations of the specific heats of hydrogen and air are fully described, and the results of all three observers compared with those of Scheel and Heuse [see Abstract No. 827 (1913)]. In the experiments observations are made at a mean temperature of about 60° C., and the various corrections peculiar to the method are determined and allowed for. From the general relation $M . C_p = M . C_v + 1986$, where M is the molecular weight, the author calculates the values of $C_p/C_v$, which agree well with the well-known directly determined values; those calculated from the determinations of Scheel and Heuse are not in such good agreement. The values of the mechanical equivalent of heat are also calculated from the various determinations by the use of van der Waals' equation, and compared with the accepted value. F. J. H.

**265.** *Anomalous Specific Heats of Certain Alloys.* **O. Richter.** (Ann. d. Physik, 42. 4. pp. 779–795, Nov. 4, 1913.)—The earlier observations of the author's on the specific heats and densities of certain alloys [Abstracts Nos. 1545 (1912) and 445 (1913)] are now examined to test the applicability of Richarz's rule to these alloys. According to this rule those alloys which depart from the law of mixtures for their densities should show a departure in the opposite direction from the same law as applied to their specific heats. This is found to be the case for Bi-Sn alloys. With Bi-Pb alloys, however, in which the departure from the law of mixtures is considerable, the rule does not apply, greater densities being accompanied by greater specific heats. The curve, specific heat plotted against percentage composition, shows a max. specific heat for a 50 % alloy, and consists practically of two straight lines intersecting at this maximum, there being, however, a slight minimum near the 100 % Pb point. This minimum no longer exists if the liquid alloy is not heated to a high temperature before casting, from which, with other considerations, it is concluded that the physical properties of certain alloys depend not only on the relative quantities of the elements used in their formation, but also on the method of casting them and upon their past thermal history. The form of the corrected curve, viz. the two straight lines, is explained by the presence of a chemical compound $Bi_xPb_x$, which alone is present at the maximum, but which on either side of the maximum is mixed with the excess of the corresponding metal. The specific heats and densities can thus be calculated by applying the law of mixtures to mixtures of $Bi_xPb_x$ and Bi, and $Bi_xPb_x$ and Pb. The author concludes that Richarz's rule applies only to alloys containing neither chemical compounds nor eutectics.

F. J. H.

**266.** *Space Lattices and Specific Heat.* **H. Thirring.** (Phys. Zeitschr. 14. pp. 867–873, Sept. 15, 1913.)—Works out the rigid integral expression of Born and Kármán [Abstract No. 626 (1913)] for the energy-content and specific heat of regular crystals as a function of the temperature and the elastic constants, by means of exponential series. Determines in this manner the specific heat of copper, rock-salt, and sylvine. The results show disagreements from the experimental values ranging from 6 to 16 per cent., but this is probably due to the use of elasticity constants applicable to ordinary as distinguished from very low temperatures. E. E. F.

**267.** *Compressibility and Difference of the Specific Heats with Liquids.* **T. Peczalski.** (Comptes Rendus, 157. pp. 770–773, Nov. 3, 1913.)—In order to obtain a formula representing the isothermal compressibility of liquids, reasoning similar to that applied to the case of gases may be employed. Thus, if $dv/v = -\alpha/\beta \,.\, dp/p$ is the differential equation for the transformation of liquids at constant temperature, and $\alpha/\beta = a - bp - cp^2 -$ etc., substitution and integration give, $\log v =$ constant $- a \log p + bp + cp^2/2 +$ etc., and hence $v = \mathrm{A}p^{-a}e^{bp + cp^2/2 + \text{etc.}}$, where A, $a$, $b$, $c$, etc., are functions of the temperature alone and $e$ is the base of the natural system of logarithms. Since at zero pressure $v$ is finite and differs from zero, $a$ must vanish in the case of liquids and solids. Thus the two equations become: $v = Ae^{bp + cp^2/2 + \text{etc.}}$, and $\alpha/\beta = -bp - cp^2$, etc., and the coefficient of compressibility, $\mu$, is equal to $\alpha/\beta p$. Taking only two terms in the exponent of $e$, the expression for $v$ gives results in satisfactory agreement with those obtained by Amagat for water at 0° and for ethyl alcohol at 0° and 40°. By means of the coefficients of expansion, $\alpha$ and $\beta$, it is possible to obtain an expression for the difference between the specific heats at constant pressure, C, and at constant volume $c$. Clapeyron's equation gives—

$$C - c = T/J \,.\, \partial p/\partial t \,.\, \partial v/\partial t,$$

in which T is the thermodynamic temperature and J the mechanical equivalent of heat. Since $\partial p/\partial t = p\beta$ and $\partial v/\partial t = v\alpha$, this gives—

$$C - c = T/J \,.\, vp\alpha\beta = Tvp\alpha^2/(J\alpha/\beta).$$

From the values thus calculated for water at 0°, it is seen that $C/c$ approximates closely to unity. This result is not in agreement with the values of $C/c$ previously calculated from the formula for the velocity of sound $V = \sqrt{(C\beta p/c\alpha\rho)}$; in the latter case the ratio $\alpha/\beta$ was taken as constant, whereas it varies considerably with the pressure. T. H. P.

**268.** *Latent Heat of Fusion.* **G. Tammann.** (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 8. pp. 335–356, 1913.)—The latent heat of fusion $r_p$ is made up of five components—

$A_e$ = Work done against external forces.
$A_i$ = Work done against internal forces.
$\Delta E$ = Difference of energy of molecules in isotropic and anisotropic state.
$\Delta \Pi$ = Difference of energy of irregular and regular molecular arrangement.
$\Delta x W_a$ = Heat-change accompanying association or dissociation, where $W_a$ is the heat of association and $\Delta x$ the change in the association factor on fusion.

At high-pressures a max. melting-point often occurs. At this point there is no change of volume on fusion; therefore $A_e$ and $A_i$ disappear, and $r_p = \Delta E + \Delta \Pi$.

The Crompton-Walden rule that $Mr/T = \text{const.}$ [where M = mol. wt., $r$ = latent heat of fusion, T = melting-point (abs.)] is of doubtful validity, since out of 157 substances tabulated only 87 give values for the constant falling within the limits 15·8 to 12·0 suggested by Walden. It is suggested that this rule can scarcely apply to those components $A_e$ and $A_i$ of the latent heat which depend on the change of volume on fusion, nor to the components $\Delta E$ and $\Delta \Pi$ which depend on the nature of the space lattice of the crystals, etc. But the two former components and the two latter only account for about 10 + 10 % of the latent heat, and larger deviations than 20 % from the Crompton-Walden rule would imply large changes in the final component $\Delta x W_a$ which depends on changes of association. This is confirmed by a comparison of the Crompton-Walden constant with the association or dissociation of the melt as deduced from Eötvös' temperature-coefficient of molecular surface energy or Walden's modified application of it. Dissociated liquids give constants ranging from 15·8 up to 128; associated liquids give constants ranging from 11·5 to 2·8; all substances giving intermediate constants are normal, so far as they have been examined, but normal liquids may also give lower constants down to 2·0; the metals give constants ranging from Bi 4·82 to K 1·84. T. M. L.

269. *Vapour Pressures and Thermometry at Low Temperatures.* **H. v. Siemens.** (Ann. d. Physik, 42. 4. pp. 871–888, Nov. 4, 1913.)—The paper describes a suitable form of vapour-pressure thermometer for low-temperature work, the instrument being a modified form of that devised by Stock and Nielson [see Abstract No. 662 (1907)]. The vapour pressures of $CS_2$, $CO_2$, O, and N are carefully determined at various temperatures by the use of suitable baths, the temperatures of which are measured by means of a Pt-resistance thermometer. This latter is calibrated by means of the observations of Onnes and Clay [see Abstracts Nos. 279 and 280 (1907)] and the Nernst reduction formula for different specimens of Pt. The observations of vapour pressure are compared in a series of tables with those of other observers, as are also the values of the latent heats calculated from them by means of the formulæ of Nernst and Berthelot. F. J. H.

270. *Vapour Pressures of Substances of Low Critical Temperature at Low Reduced Temperatures.* I. *Carbon Dioxide between* −160° *C. and* −183° *C.* **H. K. Onnes** and **S. Weber.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 215–227, Oct. 24, 1913. Communication No. 137*b* from Phys. Lab., Leiden.)—The authors have undertaken a series of determinations of vapour pressures for substances of low critical temperature at lower temperatures than in previous determinations. The measurement of the very low vapour pressures dealt with requires special methods. In measuring the pressure in a space at the ordinary temperature and connected by means of a tube with the space where the vapour and liquid (or solid) are in equilibrium at a known low temperature, correct results are obtainable only if due regard is paid to the theory of the thermal molecular pressure. This theory has been developed by Knudsen [Abstract No. 665 (1910)], who showed that, when a temperature gradient exists along a closed tube containing a gas in equilibrium, there will in general be a pressure difference between the ends of the tube, the higher pressure being observed where the temperature is higher. Pressures between 1 and 0·01 mm. have been measured by Knudsen's heated wire gauge [Abstract No. 1180 (1910)] and those between 0·01 and 0·001 mm. by Knudsen's absolute manometer [Abstract No. 1317 (1911)]. By means of the latter, the vapour pressure of $CO_2$ between −183° and −167·08° has been measured, the numbers agreeing satisfactorily with those calculated according to Nernst's formula with the constants determined by Falck [Abstract No. 1656 (1908)]. Measurements made with the heated wire gauge in the neighbourhood of −168° gave one result agreeing well with those obtained with the absolute manometer, and a second which seems to be rather too high, this being due probably to uncertainty in the temperature with the absolute manometer. T. H. P.

271. *Vapour Pressures at very Low Reduced Temperatures.* II. *Vapour Pressure of Carbon Dioxide from* −140° *to about* 160°. **S. Weber.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 445–454, Nov. 27, 1913.)—These measurements were made with the heated wire manometer previously described [see preceding Abstract], the corrections to be applied being calculated by means of Knudsen's formulæ [Abstracts Nos. 665 (1910) and 499 (1911)]. The observed results are compared with those calculated from

Nernst's vapour-pressure formula, in which the coefficients of 1/T and T are given values differing slightly from those of Falck [Abstract No. 1656 (1908)] in order to obtain satisfactory agreement at the higher pressures: $\log p = -6007{\cdot}9/4{\cdot}571\mathrm{T} + 1{\cdot}75 \log \mathrm{T} - 0{\cdot}009008\mathrm{T}/4{\cdot}571 + 8{\cdot}1700$. This formula does not give good results at temperatures much higher than −184°, the calculated and observed pressures at −129° exhibiting considerable divergence. T. H. P.

272. *Isothermals of Monatomic Substances and their Binary Mixtures.* XV. *Vapour Pressure of Solid and Liquid Argon from the Critical Point down to* −206°. C. A. **Crommelin.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 477–485, Nov. 27, 1913. Communication No. 138*c* from Phys. Lab., Leiden.)—The author gives the completed results, some of which have been previously published, of all his observations concerning the vapour pressure of solid and liquid argon. The boiling-point under atmospheric pressure is found by linear interpolation to be −185·84° K., and the triple point, which is difficult to determine owing to supercooling phenomena, lies at −189·30° K., the density of solid argon being then greater than that of the liquid. The experimental values of the vapour pressures are in moderately good agreement with those calculated from Rankine and Bose's formula, especially for the liquid-vapour region. In the case of solid-vapour, better correspondence with the experimental results is given by Nernst's vapour-pressure formula, $\log p = \mathrm{A/T} + \mathrm{BT} + \mathrm{D} \log \mathrm{T} + c$, the four coefficients being regarded as empirical and of no theoretical significance; in the field of liquid-vapour this formula is capable of representing the observations as far as the critical point in a fairly satisfactory manner and, in many cases, where the accuracy required is not very great, may be a convenient help in calculation. Moderately good agreement for solid-vapour is also shown by Sackur's formula [Abstract No. 880 (1913)]. The values of $(dp/d\mathrm{T})$ at the triple point are calculated to be 0·08162 and 0·08623 for vapour-liquid and vapour-solid respectively. The heats of evaporation at a number of different temperatures are calculated from the Clapeyron-Clausius equation. T. H. P.

273. *Reversible Adiabatic Expansion of Water.* J. R. **Roebuck.** (Phys. Rev. 2. Ser. 2. pp. 299–306, Oct., 1913.)—For the success of the determination of the mechanical equivalent of heat by the porous plug method [see Abstract No. 1971 (1913)] it was necessary to adjust the conditions such that no temperature-change would occur in a free expansion. Experiments are now described by which, with slight modifications of the same apparatus, these conditions were fully investigated. A better form of manometer was found to be necessary; accordingly a rotating piston differential manometer was designed and is fully described in the paper. For the particular pressure-change for which the gauge used in the mechanical equivalent determinations was suitable, the temperature 8·59° C. was found to be that at which there was no change of temperature with change of pressure. An attempt was also made to test whether the pressure-temperature relations for the max. density of water could be accurately obtained by this method, but the results were found not to be so reliable as direct volume measurements. F. J. H.

274. *Vapour Pressure and Density of Oxygen.* F. E. E. **Germann.** (Phys. Zeitschr. 14. pp. 857–860, Sept. 15, 1913.)—Oxygen was compressed by means of a Cailletet pump and cooled by means of liquid air and charcoal.

Its temperature was determined from the resistance of a coil of lead wire wound with tissue-paper insulation on a cylindrical block of copper containing the liquefaction tube. The pressures of the oxygen-vapour were measured by means of a standardised precision manometer. The purity of the oxygen was guaranteed by the constancy of the pressure during liquefaction. The author gives tables of vapour pressures and densities of the liquid oxygen, of which the following figures form an extract :—

| Temp. deg. abs. | Pressure. | Density. |
|---|---|---|
| 91·51 | 878·2 mm. | — |
| 92·72 | 992·3 " | — |
| 100·25 | 2·72 atm. | 1·0605 |
| 112·88 | 7·16 " | 0·9929 |
| 130·08 | 17·57 " | 0·8962 |
| 136·10 | 23·59 " | 0·8474 |

Lead has over Pt the advantage of a very regular variation of resistance at low temperatures. E. E. F.

**275.** *Critical Data of Hydrogen.* **F. Bulle.** (Phys. Zeitschr. 14. pp. 860–862, Sept. 15, 1913.)—The author adapted the apparatus used by Germann [see preceding Abstract] to the case of hydrogen by lengthening the liquefying tube and substituting a silver block for a copper block. This reduced the conduction to the exterior and increased the constancy of the temperature owing to the greater thermal capacity of the larger block. The results show that the boiling-point of liquid hydrogen is at a temperature of 20·43° abs. At 25·85° the pressure is 3·90 atmos., and at 31·85° it is 10·78 atmos. The critical temperature is 31·95° abs., and the critical pressure is 11·0 atmos. E. E. F.

**276.** *Cooling Method of Drying Air for Liquefaction.* **G. Claude.** (Comptes Rendus, 157. pp. 466–469, Sept. 15, 1913.)—The method previously used by the author for extracting water from air to be liquefied [see Abstract No. 258 (1910)] is open to the objection that traces of alcohol may accumulate in the receiver. By a suitable modification of his liquefying machine he is now able to extract the water without the addition of a foreign substance. The compressed gas is made to travel upwards instead of downwards, so that the condensed water-vapour flows back to the warmer parts of the tube, where it can be drained off, instead of forward to the colder parts, where it would freeze and block the tube. This modification, alone, however, renders the apparatus useless for higher compressions than 2 or 3 atmos., as the gas has to flow up a vertical tube in the direction of increasing density. This increase in density is considerable at the higher pressures, and the velocity correspondingly small. By sending it up the spiral tube, however, and letting the expanded gas descend by way of the central vertical tube, this difficulty is avoided. A large percentage of the water is removed in this way; the remainder, which collects in the tubes as frost, is inappreciable and allows of efficient working for upwards of 15 hours. F. J. H.

**277.** *Critical Temperature of Mercury.* **A. W. C. Menzies.** (Amer. Chem. Soc., Journ. 35. pp. 1065–1067, Sept., 1913.)—In view of the appearance of Königsberger's paper [Chem. Zeit. 135. p. 1321, 1912] the author gives his own results. When mercury is heated in exhausted and sealed quartz glass tubes of 2 mm. bore in a muffle, the liquid phase is observed to disappear at 1275°, but such disappearance is due, not to attainment of the critical temperature, but to blowing-out of the quartz tube with consequent enlargement of its volume. Quartz glass is, indeed, a supercooled liquid and the vapour pressure of mercury at 1275° is in the neighbourhood of 675 atmos. Königsberger's statement that the critical temperature lies at about 1270° is regarded as incorrect.

The relation, $a = 1/(2T_c - T)$, deduced by Davies [Abstract No. 1893 (1912)] indicates the critical temperature of mercury to be above 2600° and a similar value is given by Thorpe and Rücker's relationship, $T_c = (T_2 s_1 - T_1 s_2)/A(s_1 - s_2)$, where $s_1$ and $s_2$ are the densities of the liquid at the temperatures $T_1$ and $T_2$. Guldberg's rule connecting critical temperature and boiling-point is clearly inapplicable in this case, as it rests ultimately on the assumption that the critical pressures of all substances are nearly identical. T. H. P.

**278.** *Critical Constants of Methane.* **E. Cardoso.** (Archives des Sciences, 36. pp. 97–100, Aug., 1913.)—In continuation of his work on the critical data of readily liquefiable gases [see Abstract No. 1723 (1912)], the author has made similar determinations with methane. The apparatus used consists of a double-walled vessel which contains a liquid freezing with difficulty, such as pentane or a mixture of ether and toluene, and is immersed in a non-silvered Dewar flask charged with liquid air or oxygen. The jacket of the inner vessel is filled with hydrogen the pressure of which can be varied in order to regulate its heat-conductivity. With such an apparatus, temperatures may be maintained constant to within 0·05°. The methane examined was previously purified chemically and then fractionated in a vacuum. The critical temperature is found to be −82·85° (190·15° abs.) and the critical pressure 45·60 atmos. The critical density, determined by extrapolation from the densities of the co-existing phases over a considerable range of temperature, is 0·1623. T. H. P.

**279.** *Internal Pressures of Liquids.* **A. P. Mathews.** (Journ. Phys. Chem. 17. pp. 603–628, Oct., 1913.)—The author has calculated the values of the internal pressures, or, more accurately, those of the constant $a$ of van der Waals' equation [see Abstract No. 1096 (1913)], for a number of liquids. These values have been derived in the following five ways: (1) From the surface tension, on the assumption that the depth of the surface layer is $[T_c/(T_c - T)]^{2/3}$ molecular diameters. (2) From the law of Eötvös and T. Young. (3) From van der Waals' equation, applied to the critical temperature, assuming that $b_c$ is always $2V_c/S$, S being equal to $RT_c/V_cP_c$. (4) From the internal latent heat of vaporisation close to the critical temperature. (5) From the molecular weight and the number of valencies per molecule, according to the formula $a = 1{\cdot}259 \times 10^{11}(M \times \text{Val.})^{2/3}$. These methods give practically identical results, and with pentane and ether the values of $a$ are found to be constant over a wide range of temperature, so that, unless there is association, $a$ is constant. The values obtained are uniformly higher than those computed by others, with the exception of those recently derived by Lewis [Abstract No. 645 (1912)] from the values of the latent heats of expansion of liquids. The numbers given by Traube, Walden [Abstract No. 862 (1910)], and Davies [Abstract No. 1915 (1912)] are too low and inaccurate in other ways. The author's results confirm his conclusion that the molecular cohesion is a function of the molecular weight and of the number of valencies in the molecule. The formula $a = 27T_c^2/64 \times 273^2P_c$ gives values about 14 per cent. too low for ordinary substances and very much too low for simple diatomic gases; it should be replaced by the formula, $a = (S^2 - S + 2)T_c^2R^2/S^2(S - 2)P_c$. The results show also the inaccuracy of Stefan's conclusion, that the work required to bring particles from the interior of a liquid to the surface is equal to one-half of the work required to vaporise these particles (Wied. Ann. 29. p. 655, 1886). T. H. P.

**280.** *Combustion of Gaseous Mixtures.* **Taffanel** and **Le Floch.** (Comptes Rendus, 157. pp. 595–597, Oct. 13, 1913.)—In continuation of their previous work [Abstract No. 1448 (1913)], the authors have now determined the velocities of reaction of gaseous mixtures at temperatures below that of ignition. With air containing 6·5 per cent. of methane, the amounts of the latter burnt per sec., calculated as percentages of the mixture, are as follows: at 535°, 0·00075; at 560°, 0·0016; at 575°, 0·0025; at 600°, 0·0037; at 615°, 0·0075; at 620°, 0·0145; at 630°, 0·017; at 635°, 0·021, and at 640°, 0·050. The relation between these amounts ($da/d\theta$) and the temperature, $\theta$, is expressed by the formula: $\log da/d\theta = (\theta - 890)/70$. For mixtures containing 9 per cent. of methane and temperatures of 550–680°, the expression becomes $\log da/d\theta = \theta - 870)/60$, and for those containing 12 per cent., $dad\theta = (\theta - 880)/50$. Similar equations are obtained for air containing either 25 or 50 per cent. of CO. The limits of inflammability have also been investigated. The temperature at which the velocity of reaction with methane-air mixtures first becomes sufficient to result in the propagation of flame is about 1810°. T. H. P.

**281.** *Combustion of Gaseous Mixtures and Velocities of Reaction.* **Taffanel.** (Comptes Rendus, 157. pp. 714–717, Oct. 27, 1913.)—By means of the results previously obtained [see above], the author has made calculations of the velocities of reaction of gaseous mixtures at various temperatures. T. H. P.

**282.** *Some Properties of Explosive and Combustion Waves.* **E. Jouguet.** (Comptes Rendus, 157. pp. 545–547, Oct. 6, 1913.)—The paper is a mathematical discussion of the results acquired when a gaseous mixture capable of interaction passes from one state of known specific volume, absolute temperature, pressure, and degree of combustion, to another. The various states are represented graphically, and the curves obtained receive detailed study. In a previous paper [Abstract No. 1292 (1910)] the author has shown that certain waves should be propagated with a velocity lower than that of sound, and in consequence he has doubted their possibility. In the present paper the author admits his doubts to be a trifle exaggerated, and proceeds to demonstrate the importance of such waves from the standpoint of wave alteration during the course of propagation when limiting conditions are inadequate. These waves are now shown to have bearing on the theory of deflagrating explosions. The latter connection then receives detailed attention, and, as a result, it is found that the product of the speed of the explosive wave and that of slow deflagration is less than the square of the velocity of sound. This relation between three interesting speeds is a trifle loose since it is expressed by an inequality, although it merits special notice. It has been verified for oxygen and hydrogen, where the velocity of sound is 520 m. per sec., that of the explosive wave 2810 m., and that of deflagration about 20 m. H. H. Ho.

283. *Condensation of Water-vapour by Supersaturation.* **L. Besson.** (Le Radium, 10. pp. 318–323, Oct., 1913.)—The author has repeated the experiments of C. T. R. Wilson on the amount of supersaturation necessary for water-vapour to condense on positive and negative ions. A slightly modified apparatus was used permitting the gas under observation to be easily varied. Experiments were made with methane, $CO_2$, and air, the results showing that condensation depends on the degree of supersaturation and not on the nature of the gas. Photographs of the clouds formed under different circumstances are given. E. M.

284. *The Partition of Energy.* **J. D. van der Waals.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 401–403, Nov. 27, 1913.)—In the author's previous papers [Abstract No. 1981 (1913)] no zero-point energy was assumed. To assume zero-point energy leads to great difficulties, attributed by the author to the necessity of assuming that incident radiation sets the electron in vibration; for this would make the elementary process of absorption irreversible, whereas the co-operation of many such is observed to originate reversible phenomena. Yet, as Planck has noted [Vorlesungen über Wärmestrahlung, 2nd ed., p. 140], radio-activity can hardly be even qualitatively accounted for without assuming zero-point energy, owing to its observed independence of temperature. The presence in the atom of particles vibrating with high enough frequencies would neither give rise to radiation nor contribute to the specific heat, and with different frequencies, phases, and amplitudes, the latter varying from 0 to $8h$, an unstable configuration might occur, and therefore a radio-active explosion. But to assume the presence of such particles without connection with the zero-point energy would appear too arbitrary. The homogeneity of the $\beta$-rays from a radio-active atom, observed by Hahn and Meitner and by O. v. Baeyer, might be explained by assuming that a particle vibrating with period 8 in the atom is emitted with energy $8h$, in which case there would be close correspondence between radio-active and photoelectric phenomena, emission in the latter case arising from incident radiation, and in the former from co-operation of intra-atomic motions. The internal vibration frequency for $\beta$-rays for which $v = 0·92$ c, would then have to be $\nu = 8·25 \times 10^{19}$. Sommerfeld's value for $\lambda$ [Congrès Solvay p. 342, 1911], in the case of $\gamma$-rays corresponding to $\beta$-rays of this velocity, is $\nu = 5 \times 10^{20}$, slightly higher than corresponds to the wave-length of the corresponding $\gamma$-rays. This extremely high frequency would satisfactorily explain the observed independence of radio-activity on temperature. G. W. DE T.

285. *Enumeration of Vibrations of Solids.* **R. Ortvay.** (Ann. d. Physik, 42. 4. pp. 745–760, Nov. 4, 1913.)—A treatment of the kinetic theory on the quantum hypothesis with respect to the specific heats of solids. The formula of Debye, according to which the number of proper vibrations increases as the third power of the frequency, is thus extended to crystals as far as the rhombic system. [See Abstract No. 446 (1913).] E. H. B.

286. *Radiation and Specific Heat.* **H. L. Callendar.** (Phil. Mag. 26. pp. 787–791, Oct., 1913.)—The paper consists of notes explanatory of points raised in the author's address to Section A of the British Association in 1912. He suggests that the difference between his own theory and Planck's appears to originate mainly from the assumption of the latter for the entropy relation, $TdG = dE$, in place of the usual $dE + pdv$. The author's

theory accounts for the otherwise unexplained fact that some simple substances, such as water and mercury, show a diminution of specific heat with rise of temperature. Values for the specific heats in good agreement with experiment, at the temperature of liquid air, are obtained when the mean frequencies for the Rest-strahlen for rock-salt and sylvin are inserted in the formula derived from his theory. They are somewhat lower than those observed in liquid hydrogen, and slightly higher than those observed at higher temperatures; this, however, may be explained by supposing that the resonance is not sharply confined to a single frequency, but extends over an appreciable range. The failure of the formula deduced by Einstein from Planck's theory to give correct values of the specific heats when the Rest-strahlen frequencies are assumed may be due to its not taking explicit account of the $pv$ term in the total energy, which, the author points out, is seldom, or never, mentioned in the theory of radiation, except in the deduction of the fourth-power law, where it is universally admitted. G. W. DE T.

**287.** *Relation of the Volume-surfaces to the Polymorphism of Water.* **G. Tammann.** (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 2. pp. 157–176, 1913.)—Whilst 5 modifications of ice are known, some of them perhaps existing in more than one variety, the author finds in the $p$, $v$, T surface for water traces of six kinds of molecules, of which the last might perhaps crystallise at extremely high pressures and relatively high temperatures. T. M. L.

**288.** *Equation of State of an Ideal Monatomic Gas according to the Quantum Theory.* **W. H. Keesom.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 227–236, Oct. 24, 1913. Communication No. 30*a* from Phys. Lab., Leiden.) —Debye [Abstract No. 446 (1913)] has shown that agreement with the observations concerning the specific heats of solid substances can be obtained by modifying Einstein's theory by application of the formula given by Planck for the mean energy of a linear electrical oscillator at the temperature T to the different principal modes of vibration of a solid. The author suggests the application of the same principle to other material systems capable of functioning as oscillators, and hence the investigation of the accuracy of the consequences of the hypothesis that Planck's principle of finite elements of energy holds for each principal mode of vibration of an oscillator with motions definable by linear differential equations, no matter what the constitution of the oscillator. In the present paper these consequences are deduced for an ideal monatomic gas, with reference to the divergence from Boyle's law, the variation of the specific heat, etc. T. H. P.

**289.** *Constant of the Stefan Radiation Law.* **W. H. Westphal.** (Deutsch. Phys. Gesell., Verh. 15. No. 19. pp. 897–902, Oct. 15, 1913.)—The paper describes further measurements of the constant of Stefan's radiation law which were considered necessary by reason of the fact that recent determinations by Puccianti and by Keene [Abstracts Nos. 1858 (1912) and 688 (1913)] are higher than the value previously obtained by the author [Abstract No. 460 (1913]. The original apparatus was modified in certain particulars and the observations were extended over a wider range of temperature with a view to increasing the accuracy. The value obtained for the constant, $5{\cdot}57 \times 10^{-12}$, agrees remarkably well with the earlier determination, viz. $5{\cdot}54 \times 10^{-12}$. F. J. H.

## SOUND.

**290.** *Gramophone Improvements.* **A. A. Campbell Swinton.** (Nature, 91. p. 558, July 31, 1913.)—Describes improvements to a gramophone of the cabinet pattern which have practically eliminated the scraping noises. The lid at the top has a felt seating. The sound passes through the usual movable arm into about 14 ft. of 2-in. flexible steel pipe in six vertical lengths to the trumpet. The bends in the pipe (as in De la Rue's machine) are made of zinc, and it appears to be these bends which chiefly eliminate the scraping noises. The trumpet is of the *donkey's-ear* pattern due to S. G. Brown, and is made of four flat pieces of three-ply Birch fretwork wood of ⅛-in. total thickness. It has an oblong mouth and is shaped with *different lengths at top and bottom.* E. H. B.

**291.** *Vibrations of Telephone Membranes.* **I. M. Siegbahn.** (Ann. d. Physik, 42. 4. pp. 689–728, Nov. 4, 1913.)—Two methods are used to obtain photographic records of the motions of telephone membranes. In the first a cork communicates the motion of the telephone membrane to that of a manometric capsule, the flame from which is photographed. In the second, light is reflected from a small concave mirror attached to the telephone membrane at its place of greatest angular change. This light is received on a fixed plane mirror, a second time reflected from the moving concave mirror and then focused on a moving photographic film so as to yield a graph of the vibration. Besides many figures and tables of observations there are nine full-page plates showing the records of the various vowels. The paper includes also a theoretical treatment of the vibrations in question. E. H. B.

**292.** *Sound Effects on Passage of Alternating Currents at the Contact of Metal Point on Crystal, etc.* **R. Dongier** and **C. E. Brazier.** (Comptes Rendus, 157. pp. 587–589, Oct. 13, 1913.)—Reports an examination as to the effect of various pressures or various substances on the sounds emitted at the contact of a metallic point and crystal or another metal when used as the detector in radio-telegraphy. As to pressure, the max. sound is obtained for a certain medium value between extremes of pressure. As to materials, ordinary steel, nickel steel, German silver, manganin, nickel, and brass were put successively in contact with the same crystal and pressed so as to obtain the max. sound; but the difference between one material and another was not well marked. Manganin was best. E. H. B.

**293.** *Sound Intensity of the Singing Arc.* **H. Lichte.** (Ann. d. Physik, 42. 4. pp. 843–870, Nov. 4, 1913. Extract of Dissertation, Göttingen.)—An experimental research of which the following are the chief conclusions:—The Rihl law as to the dependence of sound intensity on arc length, on alternating and direct current strengths, for the frequencies 220–846 was confirmed and extended. The sound intensity is proportional to the square of the arc length and to the square of the alternating-current strength. For constant arc lengths and constant alternating currents the sound intensity is proportional to the p.d. at the arc. The dependence of the sound intensity on the diam. of the carbons reaches a minimum for a certain diam. This minimum diam. depends on the arc length and current. The dependence of the sound intensity on the frequency involves the square of the latter up to frequencies of 500, but for higher frequencies the fourth power is involved also. E. H. B.

**294.** *Origin of Combination Tones in Microphone-Telephone Circuit.* **E. Waetzmann.** (Ann. d. Physik, 42. 4. pp. 729–744, Nov. 4, 1913.)—The author concludes that the origin of the combination tones observed in the microphone-telephone circuit is to be referred to the kind of resistance-change of the microphone under the influence of several primary tones, and has little or nothing to do with Helmholtz's theory, though that may still be valid for combination tones afterwards formed in the ear itself. [See Abstracts Nos. 867 (1909) and 649 (1913).] E. H. B.

**295.** *Absorption of Sound by Various Materials.* **H. O. Taylor.** (Phys. Rev. 2. Ser. 2. pp. 270–287, Oct., 1913.)—For this experimental research the steady source of sound adopted was an organ-pipe with air from a chest. As this sound had overtones which were not desired a second screen or filter was employed to absorb them. This consisted of side pipes in resonance with the tones to be absorbed. The fundamental tone of the pipe then passed on in a chamber to the substance under test, and was partially absorbed and partially reflected. There are thus produced a set of stationary waves whose minima are not zero. An examination of the ratio of the maxima and minima of these waves gives the required clue to the amount reflected, and consequently to that absorbed.

As a quantitative detector for these sounds various instruments were tested, including telephones, galvanometers, molybdenite and silicon rectifiers, barretters, and microradiometers. The Rayleigh disc was finally adopted as the most trustworthy and sensitive sound-measuring instrument. The disc used was of mica, 1 cm. in radius, suspended by a quartz fibre about 10 cm. long, a small mirror being fixed to it. The disc was hung in a little wooden box with a glass front, and two 1-in. glass tubes led into opposite sides of the box. These tubes were stopped with corks so as to be in resonance with the sound in use. A ½-in. glass tube about 8 ft. long (adjusted to resonance with the pitch in use) pierced one of the corks and served to deliver the sound energy to the disc. The Rayleigh disc, thus mounted, was then used to explore the quasi-stationary waves.

Some results obtained are as in the table :—

| Material. | Coefficient of Absorption. |
|---|---|
| Smyrna rug | 0·26 |
| Brussels carpet | 0·23 |
| Hair felt (1 in. thick) | 0·51 |
| Ceilinite (½ in. thick) | 0·25 |
| Asbestos roll fire-felt (¾ in. thick) | 0·26 |
| Compressed cork (1½ in. thick) | 0·32 |

Other researches are projected along the same or similar lines. E. H. B.

**296.** *Vibrating Strings Analogous to Loaded and Unloaded Telephone Cables.* **J. A. Fleming.** (Phys. Soc., Proc. 26. pp. 61–74; Discussion, p. 74, Dec., 1913. Electrician, 72. pp. 786–787, Feb. 6, 1914. Abstract.)—The problem of determining the possible vibrations of a loaded string, that is, a flexible string having small masses attached to it at equal distances, is one to which many mathematicians have given attention. Among these are Lagrange, Rayleigh, and C. Godfrey [see Abstract 905 (1898)].

Recently the matter has acquired an electrical interest from the close analogy existing between the transmission of mechanical vibration along a loaded string and the propagation of alternating electric currents along a telephone cable having inductance coils inserted in it at equidistant intervals. In seeking for experimental methods of illustrating the properties of such loaded cables it was natural to turn for assistance to the visible oscillations produced on strings loaded or unloaded. To produce such vibrations the elegant device of F. E. Melde (in which one of the prongs of a tuning-fork sets in motion one end of the string) suffers from the following objections :—(1) A considerable tension on the string will stop the fork even if electrically driven ; (2) With long loaded strings large forks are needed to provide a low enough frequency ; (3) Any desired change of frequency needs a change of the fork ; (4) The vibrations of the string occur only in one plane, and are not plainly visible unless viewed from a certain standpoint. The author accordingly discarded the Melde arrangement for the present purpose, devising instead the following, which proved satisfactory. On the shaft of an electric motor of $\frac{1}{8}$ to $\frac{1}{4}$ h.p. is attached a disc carrying a crank-pin describing a circle about 1 in. in diameter. This pin is connected by a rod to a rocking lever, the connecting rod having a hook near each end. Thus by attaching one end of the string to either of these hooks we may give to the string a circular motion or a simple harmonic motion, and the latter may be arranged either longitudinally or transversely. The motor is fitted with a counting arrangement so as to admit of the ready adjustment of its frequency. The remote end of the string is attached to a pin with longitudinal screw traverse for adjustment of tension which is indicated by a spring balance.

This method of excitation of vibrations shows beautifully the stationary vibrations of an ordinary or unloaded string and the quite similar ones when the loads are three or more to the wave-length. The attempt to produce waves so short as to have only two loads or less per wave-length shows clearly that the waves penetrate but a small distance from their source, there being a reflection from each of the loads which soon absorbs all the energy. The reflection of waves from the junction of parts of the string with different masses per unit length is also clearly shown. The paper includes the mathematical development of the subject, and photographic reproduction of five interesting cases of the stationary waves. E. H. B.

297. *Sounding Board in Auditorium.* **F. R. Watson.** (Brickbuilder, 8. pp. 1–6, June, 1913.)—Describes with seven perspective views and sections the special sounding board designed and made to improve the acoustics of a given auditorium. The shape of the reflector was a quarter section of a paraboloid of revolution with the axis nearly horizontal. The frame was made of wood, and faced on the under side with hard plaster on wire lath. For a speaker confined to a small region this reflector distributed much of the sound over the audience and thus avoided the objectionable echoes produced when the sound passed freely to the walls. [See Abstract No. 1580 (1911).] E. H. B.

298. *Plane Waves of Sound.* **J. R. Wilton.** (Phil. Mag. 26. pp. 440–452, Sept., 1913.)—It is well known that the exact equation for plane waves of sound leads to a result which cannot hold beyond a certain time, owing to the fact that the motion becomes discontinuous. It is here shown that the ordinary approximate solution, in which the displacement is regarded as a small quantity whose square may be neglected, does not begin to depart

widely from the truth until the motion approaches the stage in which it becomes discontinuous. The mathematical investigation then follows from which these results emerge :—For a low note, just audible (say of frequency 80, and amplitude $10^{-6}$ cm.) motion of the air is such that viscosity and other influences will cause the motion to cease long before discontinuity sets in. But a high, loud note, on the other hand, gives rise to a motion which instantly becomes discontinuous. (The example worked is for a frequency of 8500 and amplitude $10^{-7}$ cm.) E. H. B.

299. *Propagation of Sound in a Heterogeneous but Non-absorbing Fluid.* **M. Brillouin.** (Comptes Rendus, 157. pp. 1135–1138, Dec. 8, 1913.)—A mathematical discussion showing that it is not the flux of the potential energy U which is conserved, but the product ($\Omega^2 U \div \Omega_\phi$), where $\Omega$ is the velocity of the sound and $\Omega_\phi$ denotes what is called the velocity of the phase. E. H. B.

300. *Musical Scales.* **A. Vaucher.** (Archives des Sciences, 36. pp. 139–158, Aug.; 239–257, Sept., and pp. 334–356, Oct., 1913.)—An elaborate examination, both mathematical and musical, of the scale and its possible temperaments. In particular the cycle of 53 commas to the octave is very fully discussed. But it is concluded that the tempered scale of 12 equal intervals is after all the most logical, the most mathematical, and that which, all things considered, responds best to the musical sentiment. E. H. B.

301. *Pianoforte Touch.* **G. H. Bryan.** (Nature, 92. pp. 292–293, Nov. 6, 1913.)—A reply to S. Pickering in which the present author expresses a preference for holding the wrists high above the keyboard for a brilliant tone and right below the keyboard for a soft tone. [See Abstracts Nos. 1177 and 1351 (1913).] E. H. B.

302. *Sound Selection by Microtelephone.* **H. Zwaardemaker.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 194–198, Oct. 24, 1913.)—By means of a Rayleigh disc the response to the voice is noted for each semitone through a range of an octave and a half, (1) without, and (2) with a microtelephone. With telephone diaphragms of different thicknesses the responses at various pitches (or tone-selections) differ widely. It is hoped that by a continuance of the researches it may be possible to supply a corrective augmentation of sound at the pitches for which a patient's hearing is defective. E. H. B.

303. *Hearing Apparatus examined by the Rayleigh Disc.* **H. Zwaardemaker.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 492–498, Dec. 27, 1913.)—The author considers that before trying to find a suitable apparatus for defective ears, it is necessary to ascertain its auditory range in the zone $a_1$ to $e_3$. The apparatus has then to supply the deficiency of the organ in this region. In the experimental part of previous researches the author used a microphone and a string galvanometer. He now adopts the Rayleigh disc and considers it unquestionably better. E. H. B.

304. *Sum of Sound Intensities in Binaural Localisation.* **G. W. Stewart.** (Phys. Rev. 2. Ser. 2. pp. 72–76, July, 1913.)—Considers the *sum* of intensities received at each ear as a factor in practical localisation of a source. It is shown by curves that this change of sum of intensities changes with the turning of the head through given angles, and changes differently for sounds of different pitches. E. H. B.

# ELECTRICITY AND MAGNETISM.

## THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

305. *Free Electrons in Metals.* **W. H. Keesom.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 236–245, Oct. 24, 1913. Communication No. 30*b* from Phys. Lab., Leiden.)—It seems natural to transfer to the theory of free electrons in metals the considerations of the former paper regarding the application of the quantum theory to the equation of state of an ideal monatomic gas. The frequencies in an electron gas, with the same order of magnitude of the number of particles per unit of volume, become very much higher than in the ordinary material gases. Hence the limiting laws deduced for low temperatures may be valid for a system of free electrons up to much higher temperatures, possibly even throughout the region which can be used experimentally. The consideration of the dynamic equilibrium between the free electrons and the electrons within the molecules of the metal leads to the supposition that at low temperatures the number of free electrons per unit of volume approaches to a constant finite value. The same is then the case for the mean velocity of the free electrons. In this manner the application of the quantum-theory to the free electrons in a metal leads, for low temperatures, to the suppositions, regarding velocity and density of electrons, on which Wien recently based his theory of electric conduction, in which theory, as previously by K. Onnes and by Lindemann, the quantum hypothesis is applied to the molecular oscillations which impede the motion of the free electrons. On the other hand, the application of the quantum-theory to the free electrons leads, for high temperatures, to the theory of free electrons in metals in the form in which it has been developed by Riecke, by Drude, and by Lorentz, and which may be called the equipartition theory. Hence the quantum-theory appears to be able to unite both the theories mentioned into one simple and coherent whole. By it, at the same time, two great difficulties, which were inherent in the equipartition theory, are solved. In the first place, it does not follow any more, as was assumed on the equipartition theory, that on approaching $T = 0$ the electrons all "freeze down," a phenomenon contradicted by the observations of K. Onnes down to the lowest temperatures at which electric conductivity has been investigated. The application of the quantum-theory given here again allows us to consider the equilibrium between the free electrons and those within the molecules as a dissociation equilibrium in the way emphasised by Koenigsberger for the theory of electric conductivity. Secondly, the difficulty disappears which on the equipartition theory followed from the small contribution made by the free electrons to the specific heat of the metal, a difficulty which appears even more sharply in the theory of the Thomson heat as pointed out by Oosterhuis.

The present author then deals mathematically with the thermoelectric power, the Peltier-effect, and the Thomson-effect. It is shown that each of these decreases to 0 for $T = 0$, the thermoelectric power and Thomson-effect finally decreasing as the cube, and the Peltier-effect as the fourth power, of the temperature. [See Abstract No. 1465 (1908).] E. H. B.

306. *Flux of Electrical Energy.* **M. Siegbahn.** (Ark. för Mat. Astron. och Fysik, Stockholm, 8. No. 31. pp. 1–21, and 9. No. 1. pp. 1–16, 1913.)—Mathematical treatment of various electrical problems on the basis of Maxwell's equations, Poynting's theorems, and the principle of relativity.
E. H. B.

307. *Electrical Units.* **P. Janet.** (Soc. Int. Élect., Bull. 3. Ser. 3. pp. 950–958, Nov., 1913.)—A statement of the relations which exist between the absolute and international electrical units, and the degree of agreement between the electrical standards of different countries. The international ohm is stated to be equal to 1·00040 ohms; the international ampere to be 0·99996 amps.; and the international volt to be 1·00036 volts. [From the references given by the author the relation between the int. ohm and the ohm should be 1 int. ohm = 1·00052 ohms, the int. volt then being 1·00048 volts. (F.E.S.).] It is believed that the int. ohm and the int. ampere may be practically realised within a few parts in 100,000, and it is shown that the standards of resistance and of e.m.f. of France, of the Bureau of Standards, of the Reichsanstalt, and of the National Physical Laboratory agree also within a few parts in 100,000. F. E. S.

308. *Nomenclature and Definitions of Magnetic and Electrical Quantities.* (Electrician, 71. pp. 1012–1014, Sept. 26, and pp. 1054–1057, Oct. 3, 1913. Report of Committee of the British Assoc., Birmingham, 1913.)—This report is in the form of a discussion on the present nomenclature and definitions of electrical and magnetic quantities together with some alterations which have been proposed, and some new suggestions. The original pages should be consulted. R. E. N.

309. *Pyro- and Piezo-electricity.* **E. Riecke.** (Archives des Sciences, 36. pp. 101–112, Aug.; 216–238, Sept.; 305–325, Oct., and pp. 405–430, Nov., 1913.)—A series of articles chiefly mathematical, and discussing the pyro- and piezo-electricity of tourmaline, including a comparison of Voigt's phenomena with experimental data, and a molecular theory of piezo-electricity. [See Abstract No. 1235 (1912).] E. H. B.

## DISCHARGE AND OSCILLATIONS.

310. *Connection between Ionisation by Collision and Electronic Affinity.* **J. Franck** and **G. Hertz.** (Deutsch. Phys. Gesell., Verh. 15. 20. pp. 929–934, Oct. 30, 1913. Paper read before the 85. Deutsch. Naturforscherversamml., Vienna, Sept., 1913. Phys. Zeitschr. 14. pp. 1115–1117, Nov. 15, 1913.)—From work on ionic mobilities [Abstract No. 1479 (1910)] Franck has shown that different gas molecules exert different forces on electrons, *i.e.* in some gases the electrons have a long life duration in the free state, whilst in others they become the centres of clusters. In the present paper it is shown that information on this question is afforded by experiments on ionisation by collision. It is well known that the currents due to ionisation by collision in He are greater than those in $H_2$, for instance. However, the minimum energy required for an electron to ionise a molecule is greater in He (20·5 volts) than in $H_2$ (11·0 volts). The reason appears to be that the collision of an electron with an atom of He is almost a perfectly elastic one, so that the electron does not lose energy, whereas in the collision with a hydrogen molecule practically all the energy is lost. Experimental evidence of this is given. Ionisation is produced in pure He (or Ne) at about 1 mm.

pressure between two electrodes. As the p.d. between the electrodes is increased beyond 20·5 volts, a point of inflection occurs in the current-potential curve, due to the production of fresh ions by collision. This shows that the energy acquired by the negative electrons between the collisions with the molecules is integrated. A further point of inflection in the curve occurs at 41, *i.e.* 2 × 20·5 volts, in further agreement with the above idea. E. M.

311. *Instability of Gaseous Ions.* **R. D. Kleeman.** (Cambridge Phil. Soc., Proc. 17. pp. 268–279, Sept. 8, 1913.)—After summarising results obtained in previous papers [Abstracts Nos. 548 and 1735 (1912)], the results of further experiments are discussed, leading to the conclusions that: (1) The period of life of an elementary ion or cluster varies largely with the nature of the gas, and is largely modified by slight admixtures of other gases; (2) the period of life of a cluster in a gas at standard pressure may have a value lying between a few seconds and a small fraction of a second. The order of magnitude of the period of life of an elementary negative ion is about 1/100 that of a cluster. The various expressions obtained by physicists for the velocity of an ion through a gas, on the assumption that it consists of an unchanging cluster of molecules, must therefore be regarded as merely useful empirical formulæ. The results also suggest a modification in the ordinary theory of ionisation by collision, as they indicate, not a current of elementary ions only, but also a current of clusters. The velocity of atomic ejection of an electron can have but little influence on the resulting ionisation by collision, as the electron will, on an average, undergo hundreds of collisions before reaching an electrode. But the direction of ejection relatively to that of the electric field will largely affect the formation of clusters. A formula is developed for calculating the life period of a positive cluster, but the absence of data precludes the deduction of any definite conclusions from it, or even as to the life period of an elementary positive ion. G. W. DE T.

312. *Theory of Photoelectric Effect.* **L. Kordysch.** (Le Radium, 10. pp. 313–316, Oct., 1913.)—The paper is partly in connection with that of Debye and Sommerfeld [Abstract No. 1859 (1913)], but deals with both the normal and the selective photoelectric effect, the former being presumed to be due to free electrons and the latter to bound electrons. It is known that the selective emission depends on the angle of incidence of the polarised light. This is provided by the theory, and it is also shown in further agreement with the theory, that in the passage of light through thin films of green malachite, fuchsine, cyanine, etc., the most absorbable wave-length (λ) depends on the angle of incidence; thus $\lambda_{70^\circ} > \lambda_{50^\circ} > \lambda_{30^\circ}$. E. M.

313. *Absorption of Kathode Rays by Metallic Sheets.* **R. Whiddington.** (Cambridge Phil. Soc., Proc. 17. pp. 280–281, Sept. 8, 1913.)—In a former paper [Abstract No. 558 (1912)] the author showed that the diminution of the velocity ($v$) of kathode rays on passing through a thickness $x$ of matter is given by the relation $v_0^4 - v_x^4 = ax$, where $a$ is a constant for each material. We are thus led to a conception of a "range" of kathode rays which is obtained by putting $v_x = 0$, *i.e.* $d = v_0^4/a$; where $d$ is the thickness of material through which kathode rays of velocity $v_0$ can just penetrate. With regard to the number of kathode rays (I) which penetrate through a sheet of matter of thickness $x$, Lenard has shown that $I = I_0 e^{-\lambda x}$, where λ is the absorption coefficient. The present experiments show that in the case of sheets, silver or gold, of thickness $d$, λ is proportional to $1/v^4$ for velocities

greater than the value of $v$ calculated from the above relation—$d = v^4/a$. In the case of copper a peculiarity is observed in the curve $1/v^4 - \lambda$ at the point corresponding to $v = 6{\cdot}2 \times 10^9$ cm. sec.$^{-1}$, this being the velocity above which the characteristic radiation of Cu is excited. E. M.

314. *The Photoelectric Effect.* **K. T. Compton** and **O. W. Richardson.** (Phil. Mag. 26. pp. 549–567, Oct., 1913.)—There are two lines of experimental investigation which have been followed in the search for the ultimate explanation of the photoelectric effect from metals. The line of investigation which has received most attention is that respecting the velocities of the emitted electrons and the relation of these velocities to the nature of the emitting metal and the frequency and intensity of the incident light. The second line of attack on this problem is the investigation of the effect of the intensity of the light, the frequency of the light, and the nature of the metal on the number of electrons emitted in unit time. The purpose of the present experiments is the investigation of the relations involved in the equation $N = Ah/R^2\nu^2(1 - e/300 \, . \, w_0/h\nu)$ when $w_0 < 300/e \, . \, h\nu < 0$; $w_0$ being the work expressed in equivalent volts done by an electron in escaping from the metal, N the number of electrons emitted per unit area, per unit time by light of unit intensity, A a constant characteristic of the metal, R the absolute gas constant reckoned for one molecule, $\nu$ the frequency of the incident light, and $h$ is Planck's constant, $6{\cdot}55 \times 10^{-27}$ erg. sec. The most striking conclusion to be drawn from the results obtained is that there are two maxima in the sensitiveness-frequency curve, instead of but one maximum as indicated by the theory and by the experiments of Pohl and Pringsheim. The discovery of this second maximum is due to the use of very electro-positive metals and to the sensitiveness of the energy calibration system used, which enabled the investigation to be carried further into the ultra-violet than ever before. The experimental results indicate that the photoelectric sensitiveness is the same function of the frequency for all metals, the difference being that the curve is shifted bodily out to the region of short wave-lengths for the electro-negative metals. This function is evidently not expressed by the equation given above, which, however, accurately predicts the values $\lambda_0$ and $\lambda_{max.}$, and seems to be at least a part of the truth. That equation is only one solution of the theoretical equations, and is probably not the only or the complete solution. The results of the investigation point to the existence of another term in the solution. If this be true, the real expression of the theory should not be the equation given, but an equation in which N equals the sum of two terms. The first term would be the right member of the given equation or something very similar to it, and would provide the first maximum and account for the "selective" effect. The second term would provide the second maximum and account for the "normal" effect. The discovery of the equation of the relation between frequency and sensitiveness would be of practical as well as theoretical importance, since it would render possible the use of photoelectric cells as the most sensitive of spectro-photometers. This solution still awaits discovery. A. E. G.

315. *Photoelectric Effect with Platinum Layers prepared by Kathodic Sputtering.* **S. Werner.** (Ark. för Mat. Astron. och Fysik, Stockholm, 8. No. 27. pp. 1–7, 1913.)—In some experiments on the photoelectric effects with Al- and Mg-layers formed by distillation in a vacuum, R. Pohl and P. Pringsheim found that the electron emission from freshly-formed layers in vacuum

increased with the time. This was found to be especially true for greater wave-lengths, and, at the same time, the limit of sensitivity was displaced towards the greater wave-lengths [see Abstract No. 1412 (1912)]. In the present experiments a special arrangement is devised so that all the incident light is absorbed. The Pt-layers which are formed by kathodic sputtering in nitrogen show, in vacuum, a large increase of the photoelectric effect, especially for greater wave-lengths; at the same time, the limit of sensitivity is slightly displaced towards the greater wave-lengths. With this increase of sensitivity, the connection between the photoelectric effect, for equal amounts of light-energy absorbed, and the wave-length of the light remains normal, an increase in the effect occurring with a decrease in the wave-length. **A. E. G.**

**316.** *The Photoelectric Effect of Metallic Compounds.* **G. A. Dima.** (Comptes Rendus, 157. pp. 590–593, Oct. 13, 1913.)—In a previous note [Abstract No. 1824 (1913)] the author pointed out that the photoelectric power of analogous compounds of the same metal depends on the valency of the metal, decreasing with increasing valency. By repeating his experiments with a radiation source rendered more constant by the use of accumulators, he has established the same result for molybdenum dioxide and trioxide. The series of manganese oxides, viz. $MnO$, $Mn_3O_4$, $Mn_2O_3$, $MnO_2$, gave a very neat illustration, for when exposed to ultra-violet light under the same conditions they emitted negative charges which may be expressed by the numbers 400, 240, 176, and 87, these being inversely as the metallic valency in the oxides. The author has made a series of comparative experiments with anhydrous and hydrated oxides, finding the best effects to be produced by the anhydrous. The case of photoelectric fatigue is next considered. The causes of the diminution of the effect with duration of exposure are not well known, and some investigators have attributed the fatigue to the presence of ozone and to gas adsorbed at the surface of the exposed body. Another explanation is that oxidation of the metal takes place in certain cases, and this would appear to be in accord with the result discovered by the author, since oxidation by increasing the valency of the metal would decrease the photoelectric effect. Therefore the higher oxides should exhibit a less fatigue than the lower. Taking the case of lead dioxide, the author found that within the limits of experimental error no appreciable fatigue could be recorded, while with lead oxide the fatigue was very rapid. Similar results were found for stannic and stannous oxides, dioxide and oxide of manganese, and mercuric and mercurous oxides. In the case of molybdenum dioxide a fatigue of 20 per cent. was found after 2½ hours' duration, while the trioxide increased its emissivity by 25 per cent., at the same time changing in colour at the exposed parts from yellow to violet. Reduction must therefore have been brought about by the ultra-violet light. On the analogy of the gradation in chemical properties between chlorine, bromine, and iodine, the author has endeavoured to ascertain whether a similar gradation occurred in the photoelectric effect. Taking a series of stable halogen compounds, he finds that except in the case of Cd the effect increases with the atomic weight of the halogen, and in every case the effect produced by Br is intermediate between those of Cl and I. Regarding the variation of the emission with time, the author finds some cases where the effect increases with exposure, and opines that here reduction must have been produced by the ultra-violet light. If such an interpretation be correct the electrometer should prove of value to chemists for studying photochemical phenomena too delicate for ordinary means of investigation. **H. H. Ho.**

**317.** *Photoelectric Properties and Contact Resistances of Thin Kathode Films. II.* **O. Stuhlmann, Jr., and K. T. Compton.** (Phys. Rev. 2. Ser. 2. pp. 327–328, Oct., 1913.)—A continuation and summary of results described in a previous paper [Abstract No. 127 (1914)]. The following additional point is noted. The saturation currents from thin sputtered films appear to be larger than those obtained from ordinary Pt. They increase approximately logarithmically with the thickness of the film and are therefore proportional to the amount of light absorbed by the film. A. E. G.

**318.** *The Photoelectric Effect.* **L. Page.** (Amer. Journ. Sci. 36. pp. 501–508, Nov., 1913.)—Compton has shown that in measuring photoelectric currents corresponding to different accelerating potentials the contact p.d. between the metal exposed to the ultra-violet and the receiving electrode must be taken into account [Abstract No. 1415 (1912)]. As this contact p.d. may amount to 1 volt or more, and as the potentials used to retard or accelerate the emission of the electrons are generally not more than 2 volts, it is obvious that serious misapprehensions may result from the failure to make correction for it. Richardson and Compton have shown that when this contact p.d. is taken into account the saturation point is independent of the wave-length of the ultra-violet light and of the nature of the metal, and always falls on the corrected axis of ordinates, *i.e.* zero volts. This leads to the conclusion that no helping field is necessary to cause the max. emission of electrons under the influence of ultra-violet light, but that any hindering field, however small, will diminish the photoelectric current. The present investigation is undertaken to verify the results obtained by Richardson and Compton, to investigate the effect of scraping in vacuum the metals which are to be exposed to the light, and to obtain, if possible, experimental evidence of the nature of the contact p.d. between metals. The special arrangement for scraping the metals is described in detail. By replacing the copper receiving electrode by one of Al it is shown that the contact p.d. should be corrected for as well when the metals which are exposed to the light have been scraped in vacuum as when they have been scraped in air. The max. energies satisfy Einstein's equation $L = h\nu - P$ provided a somewhat smaller value of $h$ is used than that usually attributed to the radiation constant. This is equally true of scraped and unscraped metals. The shift of the saturation point (the true zero potential) in the direction of increasing electro-positiveness after scraping in vacuum indicates that the constant p.d. is due essentially to a double layer on the surface of the metal. A. E. G.

**319.** *The Electric Arc in Liquids.* **W. Hallström.** (Ark. för Mat. Astron. och Fysik, Stockholm, 9. No. 2. pp. 1–14, 1913.)—Describes experiments on the electric arc in liquids, made with the object of examining the effect of cooling. Owing to experimental difficulties the only liquids used were methyl and ethyl alcohols and ethylacetate, while the electrode metals were similarly restricted to Cu, Ag, Al, and Ni. In liquids, as in gases, the arc can exist in two distinct states, the transition from one to the other occurring at higher currents in the case of liquids owing to their greater cooling effect. The two states give parallel V–I curves for each type of arc, except in the case of soft Cu electrodes, when the curves meet in a well-defined point. The results obtained were found to agree fairly with the equation $V = a + b\lambda + (c + d\lambda)/I$, where $a$, $b$, $c$, $d$ are constants and $\lambda$ is the arc length. The difference between calculation and experiment is explained by the fact that the W–I curve, formerly assumed a straight line, was found to be slightly curved. From experiments with Ag, Cu, Al and Ni in ethyl alcohol, it appears that the higher the conductivity of the electrode, the higher the voltage, Ni forming an exception. Experiments with Cu electrodes in each of the three liquids show that the voltage increases with the diffusivity of the liquid. J. W. T. W.

320. *Line Spectrum from Uncharged Molecules.* **C. D. Child.** (Phil. Mag. 26. pp. 906–911, Nov., 1913.)—Experiments are described in which under suitable conditions it is found that the luminosity of the mercury-vapour passing from a mercury lamp to a condensing chamber can be removed by the application of an electric field, which, however, does not concentrate the luminosity at any point. From these observations and the fact that the luminosity gives a line spectrum identical with that given by the arc itself, the author concludes that the light can neither be due to chemical action nor to ionisation of the vapour either in the arc or after it has left the arc; the facts, however, are readily explained on the assumption that the light is caused by the recombination of the ions to form uncharged molecules. The author has previously shown that the luminosity is not due to the absorption of radiation from the arc. F. J. H.

321. *Columnar Ionisation Theory.* **G. Jaffé.** (Ann. d. Physik, 42. 2. pp. 303–344, Sept. 23, 1913.)—The author discusses the columnar ionisation hypothesis [see Moulin, Abstract No. 1485 (1909); Wheelock, Abstract No. 115 (1911)] and derives a formula for the distribution of the ionisation density in a column and its variation with time, account being taken of the diffusion and recombination. The theoretical values for the diffusion losses in different gases and liquids are in agreement with experimental results. Formulæ are also deduced which represent the processes occurring in a column in an electric field of any direction as regards the column. The theoretical saturation curves are in accord with experiment for (1) gases under normal pressure ionised by $\alpha$-rays, (2) gases under high pressures ionised by $\beta$-rays, (3) hexane, ionised by either $\alpha$- or $\beta$-rays. The ways in which, according to the formulæ, the saturation curves depend on the direction of the electric field, on the pressure, on the linear ionisation density, and on the temperature are in quantitative agreement with the experimental observations. The diameter of a column produced by $\alpha$-rays, *i.e.* the mean distance of the ions from the axis of the column in the initial state, in different media is proportional to the range of the $\alpha$-rays. It is hence possible to calculate beforehand the saturation curves for any gaseous or liquid medium. T. H. P.

322. *The Brush Discharge.* **A. Vosmaer.** (Metallurgical and Chem. Engin. 11. pp. 623–629, Nov., 1913.)—An article dealing with the application of the brush discharge to ozone production on a large scale. The conditions necessary for the production of the three types of discharge at the atmospheric pressure, viz. the glow, the brush, and the arc, are first discussed, and the arrangement found by the author, as the result of a large number of experiments, to be the most suitable for the efficient production of ozone is described. By shunting the ozonator with a condenser and introducing a suitable inductance in the secondary of the transformer used to produce the discharge, a safety device is effected, an arc discharge being impossible with this arrangement. The author has, however, come to the conclusion that the original form of apparatus, the glass-dielectric ozonator, is the best as arcing is impossible and the conditions have not to be adjusted so precisely as in

those which have no solid dielectric. The frequent failures which have been experienced with this form through the fracture of the glass are nearly always caused by overloading. F. J. H.

323. *Electric Dispersion in Benzol, Toluol, and Petroleum.* **A. R. Colley.** (Phys. Zeitschr. 14. pp. 898–908, Sept. 15, 1913.)—Maintains that Linnitschenko's method [Abstract No. 1717 (1913)] of wire-waves is at least 10 times less sensitive than that of Colley and Obolensky, and that Linnitschenko's failure to obtain the alleged electric dispersion in benzol, toluol, and petroleum is thus accounted for. E. E. F.

324. *Measurements in the Electromagnetic Spectrum of Water with Slightly Damped Vibrations of 65–20 cm. Wave-length produced by Shock.* **H. Rukop.** (Ann. d. Physik, 42. 3. pp. 489–532, Oct. 16, 1913.)—A number of concordant measurements of the refractive index of water for very long electromagnetic vibrations give the value, 9 (8·820–9·058) at 17°. For the production of short electric vibrations, oscillators of the Settnik type [see Abstract No. 782 (1911)] were employed, the arrangement being such that the vibrations extended over about two octaves and that any wave-length within these limits could be easily obtained. The vibrations obtained were almost monochromatic and but slightly damped, the decrement being restricted to 0·04 for λ = 20 cm. and to 0·0197 for λ = 40 cm., including the resonator. With the aid of these oscillators, the refractive index of water may be determined to within 0·15 per cent. Within the region examined, water exhibits several distinct anomalous dispersion bands, but the complicated dispersion phenomena apparently found by Colley [Abstract No. 121 (1909)] could not be confirmed. T. H. P.

325. *Electric Oscillations in Thin Rings.* **C. W. Oseen.** (Ark. för Mat. Astron. och Fysik, Stockholm, 9. 12. pp. 1–30, 1913. Phys. Zeitschr. 14. pp. 1222–1226, Dec. 1, 1913.)—Highly analytical treatment, including integro-differential equations, and dealing partly with resonating circuits. E. H. B.

326. *Diffraction of Electric Waves at a Straight Edge.* **C. W. Oseen.** (Ark för Mat. Astron. och Fysik, Stockholm, 8. No. 28. pp. 1–14, 1913.)—A mathematical treatment on the basis of Maxwell's equations from which the author concludes that it is extremely unlikely that the continuous spectrum can play any essential part in the question of the radiation of electric waves round the earth. E. H. B.

327. *Coupled Oscillation Systems with Single Frequency.* **A. Kalähne.** (Ann. d. Physik, 42. 5. pp. 1001–1030, Dec. 2, 1913.)—A purely theoretical paper. The biquadratic equation, which has to be solved in the case of two coupled oscillating systems with two degrees of freedom is considered in regard to those cases in which several roots are the same or at least their real or imaginary parts are equal, *i.e.* when there is one resultant frequency for both systems or, the frequencies of the resulting oscillations being different, the damping is the same. The object of the paper is to show under what circumstances the one or other of the above three cases happens and what consequences follow. The paper falls into three parts: (1) a purely mathematical investigation into the three cases; (2) a physical part regarding the various kinds of coupling and the resulting relations between frequency, damping, and coupling; (3) a special physical part in which the theory is applied to certain special oscillation systems. T. P. B.

**328.** *Oscillations of Coupled Systems.* **S. Janss.** (Phys. Zeitschr. 14. pp. 896–898, Sept. 15, 1913.)—The "beats" of closely-coupled oscillatory circuits can be shown by means of a vacuum-tube detector (Diesselhorst). But the author has also succeeded in demonstrating them by means of Feddersen's rotating mirror. The photographs obtained, some of which are reproduced, show that the primary amplitude is a minimum when the secondary amplitude is a maximum, and *vice versa.* The frequency of beats increases with the closeness of the coupling. The action of a quenched spark is also illustrated by the same method. E. E. F.

**329.** *Effect of Ionisation of Air on Electrical Oscillations and its Bearing on Long-distance Wireless Telegraphy.* **E. H. Barton** and **W. B. Kilby.** (Phil. Mag. 26. pp. 567–578, Oct., 1913.)—Eccles attributes the bending of wireless waves round the earth to a higher velocity of propagation in the upper regions of the atmosphere owing to ionisation [see Abstract No. 109 (1913)]. Following out this idea the authors investigate the effect of ionisation of the air between the plates of a condenser in an oscillation circuit on the frequency of oscillation of the circuit. The frequencies employed are of the order of $2 \times 10^6$ per sec. Theory relating to the frequency of oscillation of a leaky condenser circuit is given. It shows that the growth from zero of a leak in a condenser at first increases the frequency, but with increasing leak the change in the frequency rises to a maximum, falls off to zero, and then changes sign. The theory is investigated by means of a Fleming cymometer, which is made specially sensitive. Across the terminals of the cymometer condenser a zinc-plate condenser is connected. The air between the plates of this condenser is ionised to varying degrees by Röntgen rays or radium rays. The cymometer is excited by an ordinary spark oscillation circuit. By means of a special electrometer resonance curves are obtained, as the ionisation of the air in the plate condenser is varied. Curves connecting change of frequency with degree of ionisation confirm the theory. T. P. B.

## ELECTRICAL PROPERTIES AND INSTRUMENTS.

**330.** *P.D. Necessary for an Electric Current through Mercury at 4·19° K.* **H. Kamerlingh Onnes.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1406–1430, July 15, and 16. pp. 118–124, Sept. 8, 1913. Electrician, 71. pp. 855–857, Aug. 29, 1913. Abstract.)—The author's investigations have been continued, the earlier result, that the almost sudden resistance change begins at 4·21° K. and ends within a fall of 0·02 deg., being confirmed and extended [Abstracts Nos. 1220 and 1042 (1911)]. Using the resistance employed in the earlier experiments, the highest limit of the value which the residual resistance can have in the case of the lowest temperature, in this case 3·65° K., was found to be $10^{-9}$ of the resistance at 0° C. (calculated for solid mercury). Next, two new mercury resistances were constructed in which it was aimed at reducing in every way the possibility of disturbances arising from the conduction of heat from a part of the apparatus having a higher temperature. The new resistances were of 50 ohms and of 130 ohms, and the threads were contained in tubes of 0·004 mm.$^2$ and 0·0016 mm.$^2$ cross-section respectively. With these the highest limit for the resistance was found to be reduced, at 3·6° K., to $< 4 \times 10^{-10}$ of the value at 0°. This heat-isolation principle was still further extended in the case of some additional threads which were built with auxiliary leads consisting of mercury "sentinel" threads of larger cross-section in order to provide a longer path before the heat could affect the "resistance" threads. With these resistances the limit was brought down, at 2·45° K., still further to $< 2 \times 10^{-10}$ of that at 0° C., the p.d. at the extremities of the thread being only 0·56 microvolt when the current density in the mercury was 1024 amps. per square *millimetre.* Mention is also made of the discovery that at these temperatures the resistance disappears also in the case of mercury amalgam and of pure tin. L. H. W.

331. *Anomalous Conduction in a Solid Dielectric.* **W. F. G. Swann.** (Phil. Mag. 26. pp. 678–693, Oct., 1913.)—An apparatus (consisting of a charged plate embedded in paraffin wax occupying the space between two other parallel plates) was used to detect the deviation, if any, of the conduction of the wax from Ohm's law.

The theory and possible errors are discussed, and it is shown that the only likely way of accounting for the results obtained is by the assumption of a departure from Ohm's law such as corresponds to an increase of the conductivity with the field. The reasons for discarding any explanation of the phenomenon as due to soakage are discussed, and the possibility of its explanation as the result of an increase in the ionisation, due to the field, is examined and found untenable. A method of accounting for the phenomenon is put forward framed on the lines of a modification of J. J. Thomson's theory of metallic conduction. E. H. B.

332. *Thermal and Electrical Conductivities of the Alkali Metals.* **J. W. Hornbeck.** (Phys. Rev. 2. Ser. 2. pp. 217–240, Sept., 1913.)—The thermal and electrical conductivities of sodium and potassium and of an equiatomic Na-K alloy have been measured by Jaeger and Diesselhorst's modification of the original Kohlrausch method, a steady electric current being passed through a cylindrical rod of the metal and the temperature and p.d. measured at three equidistant points along the axis of the rod, while the temperatures of the ends of the rod and of the surrounding jacket are kept constant. The specific resistance of sodium at 21·7° is found to be $5072 \times 10^{-9}$ ohm-cm., its temperature-coefficient being 0·00518 over the range 6–88°; the value for potassium at 20·7° is $7010 \times 10^{-9}$ ohm-cm. and the temperature-coefficient 0·00552 for 5–58°. Considering the wide difference in the methods of measurement, these results agree as closely as could be expected with Northrup's numbers [Abstract No. 888 (1912)]. The thermal conductivity for sodium diminishes from 0·321 at 5·7° to 0·288 at 88·1° and that for potassium from 0·232 at 5·0° to 0·216 at 57·4°.

The values of the ratio of the electrical to the thermal conductivity, $\sigma : \lambda$, are extremely high, but the alkali metals behave in no exceptional way as regards the absolute values of these conductivities at ordinary temperatures.

As a check on the method employed, the ratio $\sigma : \lambda$ was determined for lead at room temperature, the value obtained agreeing with that found by Jaeger and Diesselhorst [Abstract No. 187 (1900)].

A modification of the electron theory of metallic conduction is suggested which accounts for the variation of the specific heat with the temperature and also explains the curves obtained by Lees [see Abstract No. 1677 (1908)] for the ratio $\lambda : \sigma T$ for the pure metals at low temperatures [see Wien, Abstract No. 658 (1913)]. T. H. P.

333. *The Silver Voltameter.* **H. v. Steinwehr.** (Zeitschr. Instrumentenk. 33. pp. 321–330, Nov., and pp. 353–367, Dec., 1913.)—Communication from

the Physikal.-Techn. Reichsanstalt.)—The first part of this paper reviews the possible sources of error of the silver voltameter [see Abstracts Nos. 868, 1688 (1908); 187, 287 (1909); 486, 1008 (1910); 501, 508 (1913)]. The effect on the deposit of the anode liquid is considered to be negligible, and the temperature coefficient is negligibly small. The influence of reducing substances, of silk, and of oxygen, on the mass of the deposit cannot be regarded as decided, and questions connected with the volume of the electrolyte, and the solution enclosed (if any) in the deposit are not yet settled. However, in practice, the total effect must be very small. The types of voltameters most studied in recent years are those of Richards, Kohlrausch, and a new form introduced by Smith. The author thinks it better to keep the solution free from contact with possibly injurious substances, and therefore prefers the last two forms. The most recent experiments made at the Reichsanstalt give 1·01829 int. volts as the e.m.f. of the Weston normal cell at 20° C., a value which is practically identical with that adopted (1·01830 int. volts) by the International Scientific Committee on Electrical Units and Standards. Tables show the variation in the e.m.f. of the cells used to be of the order of only 1 part in 100,000 and there is evidence that these cells agree with others in various countries. The number of international coulombs required for the deposition of 1 gm.-equivalent of a substance is given as 96,494. F. E. S.

334. *The Mutual Forces between Electromagnetic Systems.* **J. Bethenod.** (Lumière Électr. 24. pp. 71–78, Oct. 18, 1913.)—If F be the force of attraction between two circuits the induction coefficients of which are $L_1$, $L_2$, if they are carrying currents $i_1$ and $i_2$, and $x$ being the distance between their centres, then it is proved that

$$F = (i_1^2/2)(\partial L_1/\partial x) + i_1 i_2(\partial M/\partial x) + (i_2^2/2)(\partial L_2 \partial x).$$

It is shown how this formula enables us to explain the working of several electromagnetic devices. A. R.

335. *Effect of Radiation on Telephone Receiver.* **I. Malmer.** (Ann. d. Physik, 42. 8. pp. 685–688, Oct. 16, 1913.)—The paper has reference to Grotrian's experiments on e.m.f. induced in the coil of a telephone receiver when radiation falls on the diaphragm [Abstracts Nos. 676 and 1198 (1913)]. The author uses a string galvanometer which enables him to follow, by photographic record, the variation of the induced current throughout the period the radiation falls on the diaphragm. The current curves are always of the same character and indicate that the effect is due to unequal expansion of the diaphragm by heat and not to a change of permeability. The bending of the diaphragm is observed by an optical arrangement.

A microphone also reacts under radiation. T. P. B.

336. *A Dust Electrical Machine.* **W. A. D. Rudge.** (Cambridge Phil. Soc., Proc. 17. pp. 249–250, Sept. 8, 1913.)—The author has previously noticed that dust clouds are capable of carrying large quantities of electricity into the atmosphere. The present paper describes an instrument designed to acquire a charge from artificially raised dust clouds. Sparks up to 5 cm. in length may be obtained in a suitably dry atmosphere. J. S. Di.

337 *A Reading Oplophone.* **E. E. Fournier d'Albe.** (Electrician, 72. pp. 102–103, Oct. 24, 1913.)—The arrangement of selenium bridges in

the "Optophone" [see Abstract No. 964 (1918)] is modified so as to give an indication of the shapes of letters through the medium of a telephone. A selenium bridge of high sensitiveness and resistance is put in series with a telephone and a battery giving 200 to 1000 volts. The selenium is illuminated by a line of light furnished by an Osram "striplite," which is concentrated on the selenium by a cylindrical water lens. A revolving brass disc with concentric circles of holes, somewhat resembling a siren disc, breaks up the line into luminous dots of various frequencies. In the instrument constructed, these frequencies are in the ratio of the notes of the major diatonic scale. When nothing is interposed between the disc and the selenium, the telephone gives out a chaos of sounds corresponding to all the notes sounded simultaneously. But when a transparency, say of a printed letter, is interposed, it breaks up the sound into distinct notes, which vary as the letter is moved past the luminous line. The various letters can then be recognised by their characteristic sounds. E. E. F.

## ALTERNATING CURRENTS AND MAGNETISM.

338. *Change in Electrical Resistance due to the Orientation of Oblate Spheroids within the Conductor.* **S. R. Williams**. (Phys. Rev. 2. Ser. 2. pp. 241–248, Sept., 1918.)—Experiments were carried out to obtain support for the assumption that a ferromagnetic substance is made up of oblate spheroids which receive a definite orientation when in a magnetic field. There can be little question that a number of factors are combined to give the effect described as change of resistance due to a magnetic field. In one metal one factor may predominate, and in another metal some other factor may hold sway. [See also Abstract No. 258 (1918).] G. E. A.

339. *Twist in Steel and Nickel Rods due to a Longitudinal Magnetic Field.* **S. R. Williams**. (Amer. Journ. Sci. 36. pp. 555–562, Nov., 1918. Paper read before the Ohio Acad. of Science, Nov., 1912.)—Besides the magnetostrictive effect, Wiedemann found that if an iron rod was first twisted mechanically and then subjected to a longitudinal magnetic field, it would also twist mechanically due to the imposed field. The paper deals with the investigation of twelve steel rods and two nickel rods. These were suspended by the upper end in a vertical solenoid, and a concave mirror attached to the lower end threw the image of a glowing filament on a slit behind which a photographic film moved. There was very little twist in the steel rods. In the nickel rods the twist rises to a maximum in a field of about 20 c.g.s., diminishes to a minimum when the field is about 35, and thereafter increases with the field. The rods not previously demagnetised show a much larger twist than those from which at least a part of the permanent magnetisation has been removed. A close inspection of the rods indicated that in the process of drawing they had been given a permanent torsional set. The conditions for a twist due to a longitudinal magnetic field seem to be (1) the presence of a permanent torsional set, or (2) the elementary magnets may be swung into spiral formations by magnetic processes. [See preceding Abstract.] G. E. A.

340. *Effect of Transverse Field on Longitudinal Magnetisation.* **A. Amerio**. (Atti dell' Assoc. Elettr. Ital. 17. pp. 1173–1181, Dec. 15, 1913.)—Continuing the investigation of the simultaneous magnetisations at right angles to each other, of G. Vallauri and others [see Abstract No. 1302 (1909)], the author magnetises an iron wire in some cases, and an iron tube in others,

by means of an external solenoid, the cycle of magnetisation being observed by means of a Braun tube. The transverse field is produced by a current in the iron wire, or in the case of the tube by a current in a copper wire situated in the axis of the tube. In all cases there is a diminution of hysteresis along with a lowering of the longitudinal susceptibility, and with sufficiently great transverse field the hysteresis vanishes. The effect is due to the transverse field and not to the direct action of the current, for in the case of the wire the effect is identical with that for the tube whenever the transverse fields are equal in the two cases. S. G. S.

**341.** *The Magneton and Planck's Constant.* **S. B. McLaren.** (Phil. Mag. 26. p. 800, Oct., 1913.)—Bohr's view of Planck's constant as an angular momentum, which was very prominent in the recent British Association discussion on Radiation, makes it of interest to note that the magneton provides a natural unit of this nature. The author finds that a magneton of any cross-section or aperture has an angular momentum about its axis of $(8\pi^2 V)^{-1} N_e N_\mu$, where V is the velocity of light, $N_e$ is the number of tubes of electric induction terminating on the surface, and $N_\mu$ is the number of tubes of magnetic induction passing through the aperture. G. W. de T.

**342.** *Kerr-effect in Ferromagnetic Compounds.* **P. Martin.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 318-331, Oct. 24, 1913.)—In continuation of a previous paper [see Abstract No. 260 (1913)] some new dispersion curves are given, and in some cases the relation between the Kerr-effect and the temperature is also given. (1) In MnAs the rotation in the yellow amounted to 1·5′ and appeared to vanish in the orange: temperature of loss of magnetism ($\theta_0$) 45°. (2) In MnSb the rotation is constant below 60° and decreases from 80° to a minimum about 265°. (3) Iron carbide showed a powerful rotation (between −18′ and −21′), with a maximum in the yellow and a minimum in the orange-red: $\theta_0 = 235°$. (4) Ferro-silicon has a powerful negative rotation increasing continuously from the violet to the red. The rotation apparently vanishes about 460°. (5) Ferro-cobalt gave the strongest rotation yet observed, the curve rising to a maximum in the red of −34′. (6) Ferro-nickel has a maximum in the yellow and a minimum in the red. Curves are also given for a number of bodies belonging to the metaferrite series. G. E. A.

**343.** *Spontaneous Magnetisation and the Assumption of a Zero-point Energy.* **W. H. Keesom.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 454-467, Nov. 27, 1913. Communication No. 32*a* from Phys. Lab., Lieden.)—The quantum theory is introduced into Weiss's theory for the ferromagnetic state, and expressions are obtained for the spontaneous magnetisation. From these, curves are drawn for magnetite and nickel in which the ratio, Spontaneous magnetisation to absolute saturation magnetisation is plotted against the ratio, Absolute temperature to absolute temp. of the Curie point. The agreement between observation and calculation is considered satisfactory in the case of magnetite. This is taken to indicate that the application of the quantum theory corresponds in its principal features to reality, particularly as regards the assumption of a zero-point energy. G. E. A.

**344.** *Susceptibility in the Excited Ferromagnetic State.* **W. H. Keesom.** Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 468-476, Nov. 27, 1913.

Communication No. 32*b* from Phys. Lab., Leiden.)—The assumption of a zero-point energy for the molecular rotations involves the possibility of the existence of ferromagnetic substances without a Curie point. If, with constant molecular magnetic moment and constant zero-point energy, the molecular field increases from zero, five cases may be distinguished of which two have no Curie point. The question of the increase of molecular magnetic moment with temperature is also discussed. G. E. A.

345. *Magnetism of Crystals and Energy at Absolute Zero.* **G. Foex.** (Comptes Rendus, 157. pp. 1145–1148, Dec. 8, 1913.)—It has been established that paramagnetic solids do not follow Curie's law at very low temperatures [see Abstracts Nos. 400 (1912) and 693 (1913)], and Oosterhuis attributes the divergence to the existence of kinetic energy of rotation of the molecules at absolute zero. The author considers that it is unnecessary to give up the classic kinetic theory. Actual experimental results do not enable us to conclude definitely for or against the kinetic theory, but arguments are drawn from Weiss's theory to show that the existence of a molecular field, when taken in conjunction with the properties of crystals, is sufficient to account for the divergence from Curie's law at low temperatures. G. E. A.

346. *Curie's Law and Energy at Absolute Zero.* **E. Oosterhuis.** (Phys. Zeitschr. 14. pp. 862–867, Sept. 15, 1913.)—The existence of a zero-point energy has been suggested by several recent investigations. Einstein and Stern have explained the variation of the specific heat of hydrogen on the assumption of a zero-point energy, and the same assumption has been found necessary to account for rectilinear translation in gases, and Keesom has shown that the quanta theory is aided by such an assumption in the explanation of the motion of force electrons in metals, several difficulties in connection with the equipartition of energy being thus eliminated. That there is a zero-point energy of rotation is supported by the magnetic susceptibility of paramagnetic substances. For most of the deviations from Curie's law found at low temperatures, of which there are three types, may be reduced to a single type, and explained quantitatively on this assumption.
E. E. F.

347. *The Magnetisability of Titanium Compounds.* **E. Wedekind** and **P. Hausknecht.** (Ber. Deut. Chem. Gesell. 46. pp. 3763–3768, 1913.)—Measurements with the following compounds of titanium: titanium dioxide and disulphide, and sulphide ($Ti_2S_3$), titanous sulphide, TiS, the oxide, $Ti_3O_5$, showed that the magnetic susceptibility increases as the valency of the Ti diminishes [compare Wedekind and Horst, Abstract No. 751 (1912)]. Titanium peroxide, $TiO_3, 3H_2O$, is feebly diamagnetic. Comparison with the compounds of Mn, Cr, and V shows that the susceptibility decreases with decreasing atomic weight, reaching its lowest value in the compounds of Ti. The oxide, $Ti_3O_5$, was obtained by heating the dioxide at 1250° for 18 hours in a current of oxygen and nitrogen-free hydrogen. T. S. P.

348. *Magneton- and Stere-Numbers of Magnetic Kathions.* **A. Heydweiller.** (Deutsch. Phys. Gesell., Verh. 15. 17. pp. 821–825, Sept. 15, 1913.)—The atomic volume of an atom or ion may be calculated from refractive moduli and in simple cases is usually a multiple of the "elementary-stere," 0·292 c.cm. per gm.-ion, the multiple being called the "Stere-number," *e.g* 2 for helium. The following table shows the stere-numbers *p* and the

magneton-numbers *n* for a series of ions whose magnetic properties have been measured :—

| | $\mathrm{Mn}''$ | $\mathrm{Fe}''$ | $\mathrm{Co}''$ | $\mathrm{Ni}''$ | $\mathrm{Cu}''$ | $\mathrm{Cr}'''$ | $\mathrm{Fe}'''$ |
|---|---|---|---|---|---|---|---|
| *p*.................... | 19 | 18 | 18 | 16 | 15 | 26 | 28 |
| *n*.................... | 29 | 27 | 24 | 16 | 9 | 18 | 28 |

The stere-numbers are practically constant for the five divalent and again for the two tervalent ions, but the latter are about 50% greater than the former, *i.e.* in proportion to the valency, in spite of the fact that the atomic volumes do not differ widely. The magneton-numbers are of the same order of magnitude as the stere-numbers. It was anticipated that they would always be smaller, the number of electrons producing an external magnetic field being less than the total number, but this is not borne out by the actual figures. T. M. L.

**349.** *Phenomena of Sun-spots and Terrestrial Magnetism.* **C. Chree.** (Roy. Soc., Phil. Trans. 213. pp. 245–277, Aug. 8, 1913.)—In a previous paper [Abstract No. 1646 (1912)] an investigation was made of the existence of any relation between the magnetic character of individual days and that of days separated from these by a given interval. The mean character figures show clearly the existence of a period somewhat in excess of 27 days, and a long analysis of the data available gives this value as probably 27·16 days. Examination of the minor pulses shows evidence of their occurrence at 54- and 81-day intervals after or before main disturbance, and the curves of magnetic character plotted in this manner are remarkably symmetrical. The results are then discussed it relation to the areas of sun-spots during the period 1890–1910. The curves of sun-spot area and magnetic character have their crests practically in synchronism, but the form of the two pulses is widely different. This tendency of a 27-day period in magnetic disturbance is apparently as clearly marked in sequences of quiet days as in disturbed days, and in years of many or few sun-spots. It was particularly prominent in 1911, when sun-spots were few. Thus, while the two phenomena appear to be related, they may be in widely different phases at the same epoch. C. P. B.

**350.** *Lunar and Solar Diurnal Variations of Terrestrial Magnetism.* **S. Chapman.** (Roy. Soc., Phil. Trans. 213. pp. 279–321, Aug. 22, 1913.)—Referring to Schuster's theory [Abstract No. 1158 (1908)], in which the diurnal variations of terrestrial magnetism are attributed to the action of e.m.f.'s produced in masses of conducting air in the upper atmosphere, by their motion across the permanent magnetic field of the earth, it is conceded as probable that the relative magnitudes of the diurnal and semi-diurnal terms in the magnetic potential arise in part from the variation of conductivity of the atmosphere with the solar hour angle, but the great excess of the summer variation over the winter variation is unexplained. In the present paper the principal facts concerning the lunar magnetic variation are summarised, and some new facts presented which have been deduced from harmonic analysis for the lunar variation at separate phases. For the discussion of these results Schuster's calculation of the effect of an atmospheric oscillation has been extended, the work being rendered simpler and more direct by adopting resistivity, instead of conductivity, as the variable. A fuller discussion of the seasonal variations will be given when the new determination of the potential of the field responsible for the solar diurnal variations, now in progress at Greenwich Observatory, is completed. C. P. B.

## CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

351. *The Oxidation of Nitrogen and Oxygen.* **W. W. Strong.** (Amer. Chem. Journ. 50. pp. 204–212, Oct., 1913.)—Referring to the researches of Strutt on afterglows and active nitrogen and of J. J. Thomson on positive-ray analysis, the author points out that, according to the latter, many ways of forming ozone and nitric oxide from different particles would be possible. Of these $\overset{-}{O_2} + \overset{+}{O} = O_3$ and $\overset{-}{O_2} + \overset{+}{N_2} = 2NO$ appear most probable to him. He then describes experiments with the "corona" discharge passing between a cylinder and its axial wire (or wires), either of which may be earthed; this corona discharge differs from the brush discharge. Drawing off the gases, when the discharge passes through air into caustic soda, he finds that the energy consumed in the formation of nitric oxide is about the same as in the several processes applied for the electric oxidation of nitrogen. H. B.

352. *New Researches on Liquid Crystals.* **O. Lehmann.** (Akad. Wiss. Heidelberg, Ber. 1913. Chem. News, 108. pp. 191–193, Oct. 17; 201–204, Oct. 24, and pp. 211–214, Oct. 31, 1913. Abstract.)—The author's experiments on ammonium oleate, as well as his theories of liquid crystals, having been criticised by Mlodziejowski, new series of experiments have been carried out in confirmation of the earlier observations. Detailed directions are given for preparing the hydrated liquid-crystalline modification of neutral ammonium oleate, and it is shown that the separate crystals possess the property of welding together when they come into contact. The "liquid crystals behave as if they consisted of mobile but approximately rigid leaflet-shaped molecules, which exercise turning moments (couples of forces) upon one another, comparable with those of astatic systems of magnets formed of revolving electrons (in paths which form knots)." T. M. L.

353. *Influence of Temperature and Pressure on the Volatility of Zinc and Cadmium.* **T. K. Nair** and **T. Turner.** (Chem. Soc., Journ. 103. pp. 1534–1548, Aug., 1913.)—The authors have continued the work on the behaviour of metals when heated *in vacuo* [see Abstracts Nos. 1458 and 1459 (1912)]. Experiments on a practical scale with 150-kg. charges showed that imperfections in the vacuum considerably diminished the rate of volatilisation of zinc, and accordingly a study was made of the rate of volatilisation of zinc and cadmium at various temperatures *in vacuo* and at various temperatures and pressures in air, hydrogen, and CO. The results show that hydrogen and CO have nearly as marked an effect as air in diminishing the rate of volatilisation. At each pressure there is a certain critical temperature, above which the rate of volatilisation is directly proportional to the temperature. This critical temperature is raised by pressure, the first increases having the most marked effect. The pressure-temperature curve for equal rates of volatilisation is steep from 0–50 mm., when there is a sudden change in direction, the curve becoming a straight line above 80 mm. Down to 50 mm., each mm. removed has a small but equal effect in lowering the rate, which is only about $\frac{1}{10}$ that of removing the last mm. F. C. A. H. L.

354. *The Allotropic Transformations of Iron.* **A. Sauveur.** (Iron and Steel Inst., Journ. 88. pp. 171–181; Discussion and Correspondence,

pp. 182–190, 1913. Engineering, 96. pp. 353–354, Sept 12, 1913.)—According to Benedicks (Ibid. 93. p. 242, 1912), when absolutely pure iron cools down to $Ar_3$ the $\gamma$ molecules are converted into $\alpha$ molecules, and there should therefore be no A2 point in absolutely pure iron. In the presence of small amounts of carbon or other impurities, the change is not complete at Ar3, but extends over a range ending at Ar2. If these views are correct, both Ar2 and Ac2 should be absent in pure iron; Ar2 should reappear in the presence of impurities, but not so Ac2, since this would imply the impossible conception of appearance of metastable $\gamma$ iron on heating. The intensity of Ar2 should increase, and of Ar3 decrease, with the amount of impurities present. Now Ac2 is found in nearly all the published heating curves of nearly pure iron—a point which has been confirmed in the author's laboratory by autographic curves of an iron of at least 99·7 % purity taken with a le Chatelier-Saladin galvanometer. All the curves show Ac2 with apparently undiminishing intensity after 12 repeated heatings and coolings. A 0·4 % carbon steel has two critical points at A32 and A1, and on Benedicks' reasoning the Ar1 point should be the retarded end of Ar32, and should not occur on heating. Again a 0·15 to 0·20 % carbon steel should by the same argument show two critical points, Ar3 and Ar1, the latter being the retarded end of the former, and no meaning can be attached to Ar2, nor should Ac2 appear on heating. To sum up: the points which have not yet been reconciled with Benedicks' theory are:—(1) It has not been shown that Ar2 is absent in absolutely pure iron; (2) Ac2 is always present in autographic heating curves of pure iron; (3) the point Ac2 or Ac32 is generally detected in steels containing less than 0·6 % carbon; and (4) iron loses the bulk of its magnetism at 780° to 800° C., and not at Ac3. F. C. A. H. L.

355. *Crystallising Properties of Electro-deposited Iron.* **J. E. Stead** and **H. C. H. Carpenter.** (Iron and Steel Inst., Journ. 88. pp. 119–145; Discussion and Correspondence, pp. 146–170, 1913.)—Stead showed in 1898 that the fine grains of practically carbonless irons and steels are slowly increased in size by heating at 500° C. and more rapidly increased in size by heating between 600° and 750° C. Iron made coarsely granular at 700° C. is not affected by subsequent heating until the temperature exceeds 900° C., when the granules again become small. Subsequent work showed that the largest crystals are produced at 700° to 740° C., and that the refining is definitely connected with the A3 change. The authors carried out a number of preliminary experiments on electro-deposited iron of 99·967 % purity, available in the form of finely crystalline strips, 0·25 mm. in thickness and resembling pure copper in malleability. On heating to 920° to 970° C. it formed very large crystals which could only be refined by cold work followed by annealing at 750° to 800° C. Thus the conditions which coarsen the crystals of electrolytic iron refine those of mild steel and wrought iron, and the conditions which coarsen the crystals of the latter are without effect on those of the former. This astonishing difference caused the authors to undertake a study of the conditions under which the structures of strips of electrolytic iron, mild steel, and decarbonised wrought iron are coarsened and refined. Electrolytic iron is found to develop enormous crystals after heating to above Ac3 and cooling below Ar3. Although two types of crystals "equi-axed" and "columnar" are produced (frequently on the same specimen), they are not constitutionally different and most likely both are $\alpha$ iron. Prolonged heating above Ac3 followed by slow cooling does not produce coarse crystals, probably because of the gradual destruction of the $\alpha$ nuclei.

Further, the crystallisation effect appears to be a function of the thickness of the sheet, and is not obtained when the thickness exceeds a certain critical figure, the most striking effect being obtained at a thickness of about 0·01 in. Once formed, the coarse crystals can only be destroyed by cold work or by quenching from above 950° C. The experiments on wrought iron and mild steel which have been rendered coarsely crystalline by annealing at 700° to 800° C. show that they are refined by heating to the temperature (920° C.) at which electrolytic iron is coarsened. The results give no support to the view that there is any crystallographic difference between $\beta$ and $\alpha$ iron, and are best explained on the assumption that at $Ar3$ the iron changes direct from the $\gamma$ to the $\alpha$ condition. F. C. A. H. L.

**356.** *Transformations of Iron and Steel at High Temperatures.* **K. Honda and H. Takagi.** (Rev. de Métallurgie 10. pp. 1326–1336, Dec., 1913.)—Whilst a transformation in a body is accompanied by a change in one or more of its properties, the whole of the properties are not necessarily affected, so that in studying transformations it becomes necessary to make simultaneous observations of the variations in several properties. This the authors have done by noting the time, temperature of, and magnetic properties of Kahlbaum's pure iron, samples of steel containing 0·14 to 1·50 % carbon, and a tungsten steel containing 5 % W and 0·6 % carbon, during heating and cooling. The results show that in pure iron the $\beta \longrightarrow \alpha$ change takes place in a very small interval of temperature, the change in the magnetic curve being very abrupt at 765° C. The interval corresponding to the transformation $\beta \longrightarrow \alpha$ or $\gamma \longrightarrow \alpha$, increases with increase of carbon. In steels there is not much heat liberated in the $\beta \longrightarrow \alpha$ or $\gamma \longrightarrow \alpha$ changes, but the pearlite separation is accompanied by a large evolution of heat and an increase in the permeability. The temperature of the pearlite formation is 30–40° higher on heating than on cooling. Recalescence is to be attributed to the deposition of iron from the solid solution and not to the $\beta \longrightarrow \alpha$ or $\gamma \longrightarrow \alpha$ polymorphic transformations. F. C. A. H. L.

**357.** *So-called "Crystallisation Through Fatigue."* **F. Rogers.** (Iron and Steel Inst., Journ. 88. pp. 392–396; Correspondence, pp. 397–398, 1913. Mech. Eng. 32. pp. 213–214, Sept. 5, 1913. Engineering, 96. p. 525, Oct. 17, 1913.)—The idea that crystallisation is caused by fatigue has been prevalent for many decades, but there has never been any direct experimental evidence in support of this view. Experience has shown that material which breaks in service with a crystalline fracture would have given the same type of break had it been broken when new. Neither does fatigue generate crystalline fracture in a material initially breaking with a fibrous fracture. Examination of a wrought-iron centre post which broke in use with a partially fibrous, partially crystalline fracture, a type generally ascribed to "crystallisation through fatigue," showed that the material had been built up of different grades of iron during piling. F. C. A. H. L.

**358.** *Heating and Cooling Curves of Manganese Steel.* **R. A. Hadfield.** (Iron and Steel Inst., Journ. 88. pp. 191–196; Discussion and Correspondence, pp. 197–202, 1913.)—Inverse-rate heating- and cooling-curves have been taken of cast and forged specimens of two Mn steels containing 1·26% carbon, 0·32% Si, 13·38% Mn, and 1·16% carbon, 0·21% Si, 10·85% Mn respectively. No critical points were observed between 1350° and 150° C., and all the specimens remained non-magnetic during the whole of the treatment.

Considered in the light of the remarkable changes produced in the structure and mechanical properties of Mn steels by slow cooling or quenching, the absence of critical points is remarkable. More recent work with Hopkinson indicates that Mn steels can be made magnetic by prolonged heating at 450° to 500° C. and that in this condition the steel shows a critical point commencing at about 680° C. F. C. A. H. L.

**359.** *The Critical Points Ar*1, *Ac*1. **J. E. Stead.** (Iron and Steel Inst., Journ. 88. pp. 399–409; Correspondence, pp. 410–415, 1913. Engineering, 96. pp. 354–356, Sept. 12, 1913.)—The steel to be tested is forged into bars of convenient size (approx. 10 × 5 × 115 mm.) which are then filed or ground on all sides to remove the decarbonised skin. Asbestos packing is placed between two bars in such a way as to leave a central passage 1·5 mm. wide between them; the whole is bound together with thin wire and pushed into a porcelain tube in the side of a muffle heated to 1000° C. After 30 mins. there is a constant temperature gradient along the bars determined by introducing wires of silver, silver coated with common salt, of Al, and Zn into the passage and withdrawing them after 3 mins. From the length of the wire remaining unmelted the temperature at four different points on the wire becomes known and a curve can be plotted showing the temperature gradient along the bars, which are then withdrawn, quenched in cold water and one face polished and etched. A sharp line of demarcation is developed between the hardened and soft portions of the bar; the temperature which existed at this point can be obtained from the temperature gradient curve and represents the temperature of Ac1 to within 3 deg. C. Ac1 and Ar1 can be determined in the same operation by heating two bars of the same steel together and slowly drawing out one of the bars for 15 mm. after the heat is constant. The heating is then continued and the bars are treated as above. After etching the bar drawn out has the point Ar1 marked upon it, and the other bar the point Ac1. F. C. A. H. L.

**360.** *Method of Measuring the Viscosity of the Vapours of Volatile Liquids, with an Application to Bromine.* **A. O. Rankine.** (Roy. Soc., Proc. Ser. A. 88. pp. 575–588, July 18, 1913.)—This method is based on O. E. Meyer's transpiration formula, the older methods being modified by the use of special devices for estimating the pressures at the two ends of the capillary tube and for measuring the quantity of gas passing through it. Each of two carefully calibrated U-tubes of about 2 mm. bore and 20 cm. length of limb is connected at one end with a capillary tube about 89 cm. in length and approximately 0·018 cm. radius. One of the U-tubes is filled with the liquid to be examined and the apparatus is exhausted and sealed. The tubes are enclosed in baths at constant known temperatures, chosen to evaporate and condense the liquid respectively. The connecting capillary is surrounded by a third bath at an intermediate temperature, at which the viscosity of the vapour is to be determined. The amount of the substance passing over is determined from the alteration in volume of the liquid in the U-tubes. The apparatus being symmetrical, measurements in alternate directions may be performed successively. The apparatus, both in its final form and during the process of filling, is entirely devoid of taps, absence of tap grease being regarded as necessary in order to avoid the production of impurities due to chemical action on it of the bromine, with which viscosity measurements were made at temperatures varying from 285·9° to 498·4° abs. The values found for $\eta \times 10^4$ in c.g.s. units at different absolute temperatures are: 498·4°, 2·480 ; 452·8°, 2·273 ; 412·8°, 2·079 ; 372·8°, 1·885 ; 338·8°, 1·705 ; 285·9°, 1·511. These values agree well with those obtained by the author by another method [see Abstract No. 685 (1912)] and, with the exception of those for the two lowest temperatures, are in accord with the numbers calculated from Sutherland's equation.

Although various gases, without distinction of kind, obey approximately the law, $T_c/C$ = constant, where $T_c$ is the absolute critical temperature and C Sutherland's constant, still better agreement is obtained among the members of a single group of the periodic system. Further, it has been found that, for the group of inert gases the square of the viscosity at the critical temperature is proportional to the atomic weight or $\eta_c^2/A$ = constant $= 3·98 \times 10^{-10}$, where $\eta_c$ is in c.g.s. units and A is the atomic weight relative to oxygen. With Cl and Br, the values of this constant are $1·02 \times 10^{-9}$ and $1·03 \times 10^{-9}$ respectively, so that the law seems to possess wider application than merely to the inert gases, the constant having different values for each group in the periodic table.

The values of the viscosity are used to estimate the molecular magnitudes of Cl and Br, the diameters being 3·15 and $3·36 \times 10^{-8}$ cm. and the volumes 1·80 and $1·59 \times 10^{-23}$ c.cm respectively; the density of the atom of Br hence seems to be about twice as great as that of Cl. T. H. P.

**361.** *New Electrical Method of Preparing Aqueous Colloidal Solutions of Metals.* **H. Morris-Airey** and **S. H. Long.** (Univ. of Durham Phil. Soc., Proc. 5. pp. 68–70, 1912–1913.)—In order to combine the advantages of Bredig's and Svedberg's methods for preparing colloidal solutions of metals, the authors make use of a high-frequency alternating arc. A suitable generator is found in the Poulsen arc as used in wireless telegraphy, leads being taken from two points on the inductance of the oscillatory circuit of the arc to the terminals of a discharger circuit consisting of an arc lamp designed to allow of the arc being struck under water. The frequency could be varied from 223,700 to 365,200 per sec., the current in the discharger circuit from 0·14 to 15 amps., and the voltage from 430 to 4030; the length of the arc in the discharger could also be varied. In general, only a few seconds are required to produce colloidal solutions of Au, Ag, Pt, Pd, Cu, Pb, Fe, Zn, Sn, Ni, Al, Mg, Bi, Sb, or Cd; solutions of carbon were also prepared. Certain colours have been regarded as characteristic of the colloidal solutions of many of the metals, but the above method shows that the colour is a result of the special conditions of the discharge. Where only one or two colours had been previously obtained, the authors found it possible, by suitable adjustment of the conditions, to obtain a wide range of colours with several metals. Thus, with gold, red, blue, and purple solutions are obtainable as well as a number of intermediate colours; examination of these colloids with a Hardy tube indicates that the red and blue hydrosols carry charges of opposite signs, while the purple one appears to be a mixture of the other two. Similar results are given by other metals. T. H. P.

**362.** *Colour-changes in Colloidal Gold.* **S. H. Long.** (Univ. of Durham Phil. Soc., Proc. 5. pp. 113–118, 1912–1913.)—The results of further experiments [see preceding Abstract] lead to the following conclusions: (1) Red colloidal gold in water is associated with the hydroxyl ions and moves to the kathode; in this solution the particles are very small. This colloid may be represented by the formula, $n\mathrm{Au}^+ + \mathrm{H}^+\,\mathrm{OH}^- = \mathrm{Au}_n^+\,(\mathrm{OH})^- + (\mathrm{H})^+$; in dependence on the conditions under which the gold was dispersed under the water, a group of particles received a positive charge, and on entering the disperse medium became associated with the negatively charged hydroxyl ions to form a gold-hydroxyl aggregate. This may be looked upon as a group of gold particles surrounded by an atmosphere of hydroxyl ions. (2) Blue colloidal gold in water is associated with the hydrogen ions and moves to the anode; in this solution the particles are larger than in the case of red colloidal gold. (3) Purple colloidal gold is simply a mixture of the red and blue colloids, the relative proportions of which determine the particular shade of purple. (4) The more stable form of gold colloid is the blue, into which the red may be changed by the action either of an electrolyte or of an electric field. Change from the red to the blue form is accompanied by change in the absorption spectrum from a large band extending throughout the orange region to a band of about one-sixth this length and with very sharply defined edges. T. H. P.

363. *Importance of Viscosity for Study of Colloidal State.* **W. Ostwald.** (Faraday Soc., Trans. 9. pp. 34–46, July, 1913.)—Attention is directed to the great variability of viscosity in colloids: this is affected, not only by temperature and by concentration, but also by the "degree of dispersity," *i.e.* the size of the suspended particles, and in many cases by previous thermal or mechanical treatment. The magnitude of the viscosity varies over an extraordinary range, *e.g.* in a colophony-turpentine sol from 1 to $10^{20}$ in the range between 0 and 100 %; extreme changes may occur within a range of 1 % of concentration or 1 deg. of temperature, which is often sufficient to cause the settling of a colloid that was previously quite fluid. No better method exists of studying the changes that precede the setting of a colloidal solution than the measurement of viscosity-changes. The viscosity also reveals on an enormously magnified scale the small effects that are produced, *e.g.* by acids and alkalies on osmotic pressure. All these observations emphasise the correctness of Graham's dictum "that a liquid transpiration tube [*i.e.* a viscometer] may be employed as a colloidoscope." T. M. L.

364. *Experimental Determinations of Drop-electrode Potentials in Mixtures of Water and Alcohol.* **H. Krumreich.** (Zeitschr. Elektrochem. 19. pp. 622–636, Aug. 15, 1913.)—The arrangement is described in detail. The jet is on the Paschen plan, the separation into drops beginning in the level of the liquid, and the observations are checked by measurements with the capillary electrometer. When the liquid above the mercury is water, some depolarisation of the jet potential, by diffusion and convection owing to the slight solubility of mercurous salts in water, will take place even on the Paschen plan; but it is much smaller when alcohol, of different concentrations, is used in the place of water. The author determines this depolarisation and then the potentials in alcoholic solutions of $KNO_3$ of various concentrations. H. B.

365. *A New Grove Cell.* **K. Siegl.** (Elektrotechn. Zeitschr. 34. pp. 1317–1318, Nov. 13, 1913.)—Briefly reviewing the extensive literature on Grove cells and his own experiments with cells consisting of Pt electrodes, coated with platinum black and dipping into sulphuric acid, the one surrounded by hydrogen, the other by oxygen (or other gases), the author comes to the following conclusion. Immediately after closing the circuit all the parts are active in generating electricity; the occluded gas is consumed, and new gas is absorbed by the portion of the electrode above the liquid, whilst the

portion within the liquid becomes polarised with respect to the upper portion, and the e.m.f. decreases. The electrodes should hence have large surfaces and should discontinuously be brought into contact with a diaphragm, which forms the gas chamber and which is moistened with the electrolyte. The scanty descriptive details offered hardly explain how this is realised in the new cell. The electrodes are platinised grains of carbon, 8 mm. in diam., and carbon plates in shallow clay cylinders charged with the gas and with sulphuric acid (hydrochloric acid, when chlorine gas is used). Cells of this type are said to be economical: Cl-H cells give 1·4 volts at an expenditure of 0·43 mark per kw.-hour, O-H cells 0·9 volt at 0·85 mark and air-illuminating gas cells 0·7 volt at 0·17 mark. Pressure, from 1 cm. of mercury to 5 atmos., does not influence either the e.m.f. or the current. The cells are supplied by C. Schniewindt, of Neuenrade, Westphalia. H. B.

**366.** *Electrolytic Sodium Hypochlorite with Cooled Anode.* **P. H. Prausnitz.** (Zeitschr. Elektrochem. 19. pp. 676–680, Sept. 1, 1913.)—Working with a tubular Pt anode consisting of an inner tube and a jacket, through both of which water is flowing in series, the author finds that in 5-*n*NaCl solutions the yield of hypochlorite was 41·6, 90, and 100 gm. of Cl per litre respectively, when the anode was left uncooled or cooled to 15° or to 4° C. Such energetic cooling is, however, not required, provided the anode is kept at about 20°, whilst the electrolyte, warms up to 48°; up to 70 gm. Cl are then gained. When the brine contains the normal NaCl solution, cooling is of little avail. The current density should be about 1·25 amps./cm.$^2$. The yield can further be raised by platinising the anode. H. B.

**367.** *Valve Action of Zirconium Anodes.* **L. H. Walter.** (Electrician, 71. pp. 1057–1058, Oct. 3, 1913.)—Zirconium anodes have been prepared from small crystals of Zr, a surface of 8 mm. by 2 mm. of zirconium being left exposed. Using these electrodes as anodes, it is shown that the ratio of the resistance in the effective direction to that in the non-effective direction is of the order $10^6$. A series of measurements of the leakage current at various potentials is given for solutions of 8 % sulphuric acid, sodium tungstate, lithium citrate, ammonium borate, potassium dichromate, and sodium carbonate. In the case of sulphuric acid the valve action breaks down at about 105 volts, whilst in other solutions a higher potential can be applied without destroying the valve action. As in the case of tungsten [see Abstract No. 2152 (1909)], zirconium is very sensitive to the cutting off of the current. The question as to whether rectification occurs on alternating current is not yet decided. Zirconium is the only metal of the fourth group of the periodic system which has been shown to exert a valve action. L. H. W.

**368.** *Ultramicroscopic Investigations of the Cataphoresis of Colloidal Solutions: A Theory of Coagulation.* **M. Kimura.** (Kyōtō Coll. Sci. Engin., Mem. 5. pp. 175–199, May, 1913.)—The author has made ultramicroscopic investigations on an electrolytic cell constructed by placing two pieces of Pt-wire, 20 μ in diam., in parallel positions a fraction of a mm. apart, on a clean plate of fused silica or glass, introducing a drop of colloidal silver solution between the wires and covering with another quartz or glass plate; a current was passed through the liquid under observation. From the results obtained the following conclusions are drawn:—The electric double layer covering a colloidal particle remains undissociated in an ordinary state; the dissociation of double layers, and, consequently, the translational motion of colloidal particles, occurs only by the current motion of electrolytic ions. In their motion towards the electrodes dissociated colloidal particles collide with electrolytic ions and undergo variations in the amounts of the charges carried. When the current is cut off, particles soon become covered again with double layers. When an electric current flows through a colloidal solution, part of this current is generally carried by colloidal particles. When an electric current is sent through a solution containing so-called negative colloids, some of these change into positive ones. In a colloidal solution prepared by Bredig's method the charge possessed by the dissociated particles varies from particle to particle. When a current passes through a colloidal solution, the aggregation and coagulation of particles take place among the oppositely charged dissociated particles when these approach one another very closely. The first stage in the coagulation of a colloidal solution by an electrolyte is the formation of the positive and negative colloidal particles, the second stage being the union of the different particles thus formed. The coagulation of a platinum hydrosol is caused easily by the bubbling of oxygen, but not by that of hydrogen, through the liquid. T. H. P.

369. *Electrolysis of Potassium Chloride.* **H. S. Lukens.** (Amer. Chem. Soc., Journ. 35. pp. 1472–1482, Oct., 1913.)—In the electrolytic estimation of anions, using the Hildebrand cell, only small quantities of salt can be used. The author has investigated the accuracy which is obtainable when solutions of potassium chloride containing 1–2 gm. of the salt are electrolysed. It was found that the chief error was caused by the anolyte creeping into the katholyte under the glass partition (cup) separating the anolyte and katholyte, owing to the fact that glass is not wetted by mercury. This could be prevented by platinising the bottom edge and outside of the cup, and then depositing a heavy coating of silver on the Pt. There was still a slight error caused by some decomposition of the amalgam occurring in the inner cell. This was obviated by cutting a section, 8 mm. in height, from the bottom of a beaker 40 mm. in diam.; this was cemented in an inverted position in the centre of the crystallising dish containing the mercury. When the glass cup was then placed in position the mercury in the anode portion of the cell was confined to an annular space, about 10 mm. wide, between the cup and the section from the beaker, whereby the amalgam was formed close to the outer vessel, into which it quickly made its way and was decomposed. The results obtained with this apparatus were very accurate, the errors being of the order of 0·0001–0·0003 gm. on 0·6 gm. of chlorine. 1·09 gm. of potassium chloride could be decomposed in an hour, using 1·6–2 amps. at 6·5–7 volts. T. S. P.